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WHEN BLACK HOLES TURN WHITE

Has a new detection finally revealed the ultimate theory of life, the universe and everything?

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The weird explosion that's got astronomers talking

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Told for the first time by the influential scientist's son

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NASA's Mars Reconnaissance Orbiter continues to supply wonderful images of Mars

Welcome

This month **All About Space** gets to the bottom of what happens when black holes turn white. It turns out that these mysterious, high-gravity objects have a penchant for exploding, becoming their exact opposites and, rather than 'sucking' everything in, they blow everything out. I am, of course, talking about the white hole, and it seems that they can reveal quite a bit about the nature of the fabric of space and time. Turn to page 16 for Colin Stuart's full report on this incredible new breakthrough in research.

Elsewhere in the issue, **All About Space**'s Staff Writer Lee Cavendish digs deeper into the recent discovery of organics in the plumes shooting out from the surface of icy moon Enceladus, which orbits ringed giant Saturn. What does this mean for our hunt for life in our Solar System? What could this life be like? Do scientists think that we've finally struck gold?

If you've ever wondered where we're at in our developments to travel faster than light, then look no further than this issue; we speak to the researchers who have considered everything from warp drives to wormholes in our efforts to beat the cosmic speed limit.

Lastly, we're starting to move into observing season, so there's plenty for you to get stuck into with our ultimate guide to the planets, naked-eye targets and deep-sky challenges.

Enjoy the issue!

Gemma Lavender
Editor

Our contributors include...

Giles Sparrow
Author & astronomer
After speaking to the physicists behind the research, Giles has the lowdown on how we intend to break the cosmic speed limit with future technologies.

Colin Stuart
Author & astronomer
Colin reveals what a black hole's transformation into a white hole means for our understanding of not just the fabric of space and time, but also of the theory of everything.

Jonathan O'Callaghan
Science & technology journalist
China's Long March 9 rocket is tipped to be a souped-up version of the Saturn V. Jonathan finds out more on page 48.

Stuart Atkinson
Seasoned astronomer
Stuart provides the tutorials and observing tips and tricks you have to try out this season. His observer's guide to the night sky begins over on page 74.

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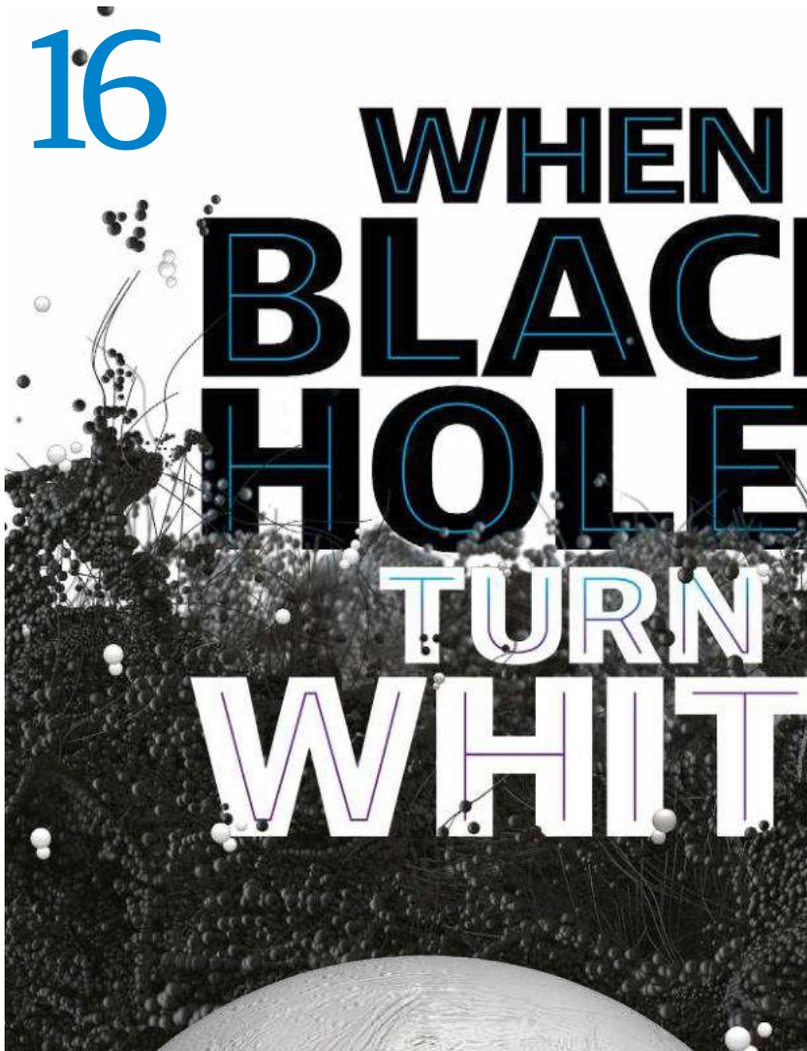

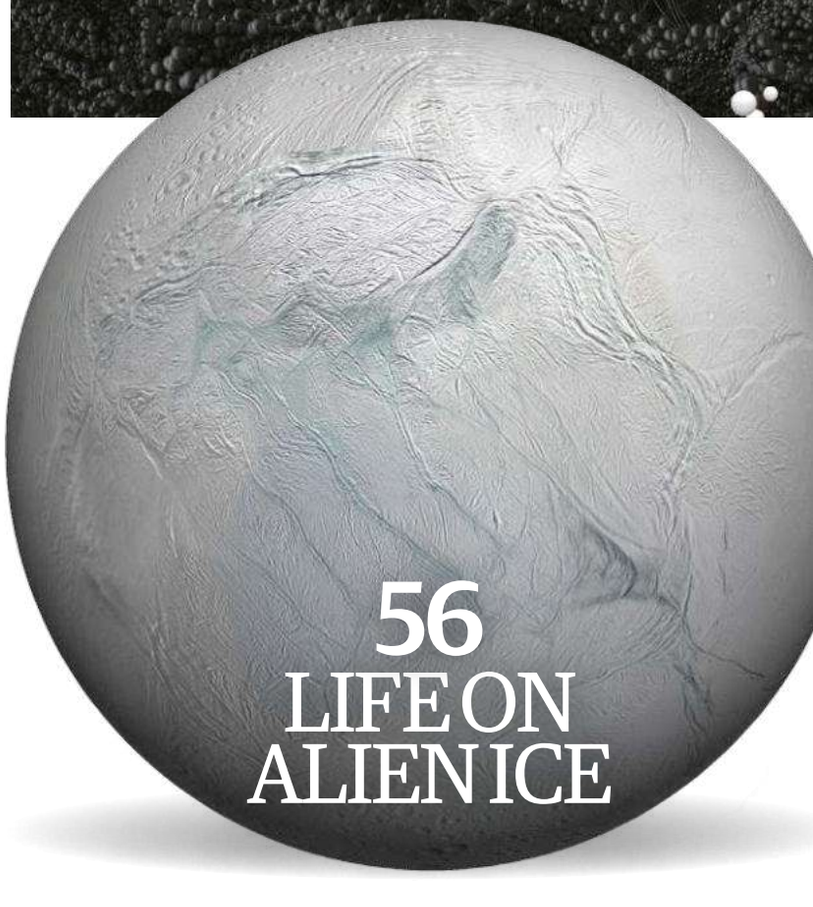

"My dad never pushed me into astronomy. He just wanted me to find my own path"

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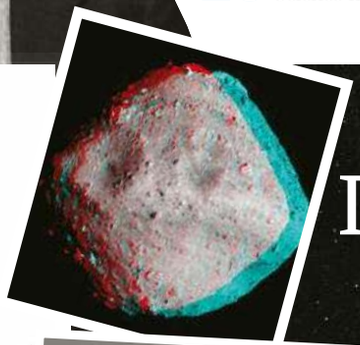
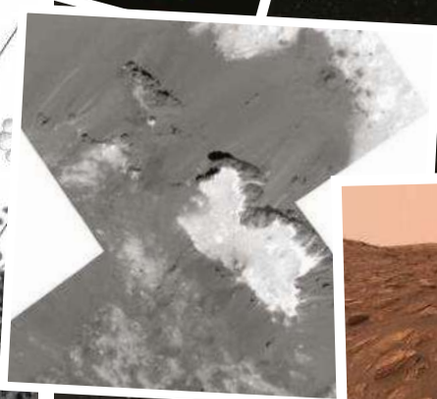
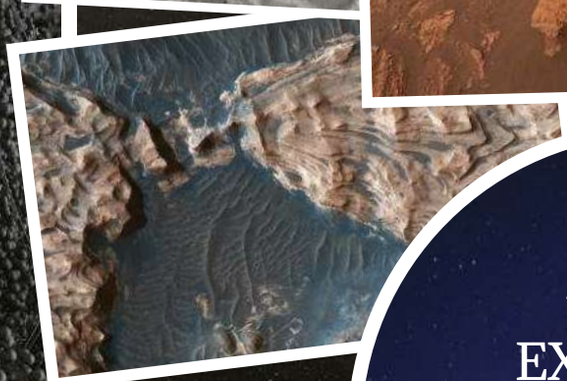
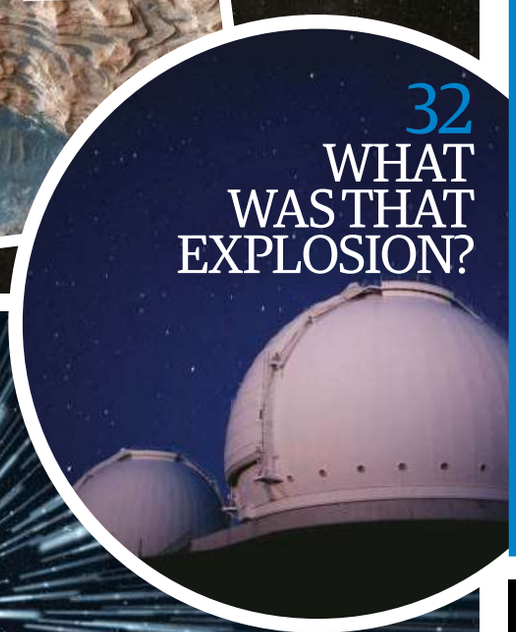
Science-fiction writer and son of Carl Sagan









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X-periencing the Pillars of Creation

The Eagle Nebula, also known as Messier 16, is one of the most famous nebulae around as it contains an iconic feature within: the Pillars of Creation. These pillars are long stretches of gas and dust from which stars are born. It was famously first photographed by the Hubble Space Telescope in 1995 and continues to be the subject of the long-serving spacecraft, jointly operated by space agencies ESA and NASA.

In this updated photograph, X-ray observations from NASA's Chandra X-ray Observatory have been combined with optical data to reveal the extreme energies being emitted from the hot outer atmospheres of stars.

Cluster of colour

Yet another vibrant piece of celestial artwork has been imaged by the European Southern Observatory's (ESO) Very Large Telescope (VLT), situated in Chile. This time the VLT pointed its powerful optics, consisting of four 8.2-metre (27-foot) telescopes, at the stunning star cluster RCW 38.

This image was taken in order to test out the new HAWK-I camera on the Ground-Layer Adaptive Optics Assisted by Lasers (GRAAL) instrument. The test proved a success as it was able to return this magnificent image, revealing the contrast of colours that are brought about by the illumination of young, bright stars and protostars, which are even younger stars still gathering mass from the surrounding gas cloud.

Caught in the middle

Stuck at an altitude of approximately 400 kilometres (250 miles), being on the International Space Station presents visual opportunities that are impossible while on Earth. This is why having the European Space Agency's (ESA) Alexander Gerst up there with his camera is extremely gratifying. Observing black space with the Moon shining above the blue atmosphere with clutters of clouds is a view that can only been seen while working on board a revolutionary space station.

Reminiscing on a failed supernova

About 70 million light years from Earth in the constellation of Pegasus (The Winged Horse) is the irregular galaxy of UGC 12682. Pictured here by NASA/ESA's Hubble Space Telescope, astronomers look at this image and reminisce about the time a 14-year-old girl from New York, United States, discovered an extremely peculiar supernova within this galaxy, known as SN 2008ha.

Further observations showed that SN 2008ha was one of the faintest supernovae ever discovered and was found in this galaxy that rarely produces stellar explosions. After its initial eruption it expanded very slowly, which suggests it didn't have the energy for a full stellar outburst. This led scientists to put SN 2008ha down as a failed supernova, as it failed to destroy the whole star.

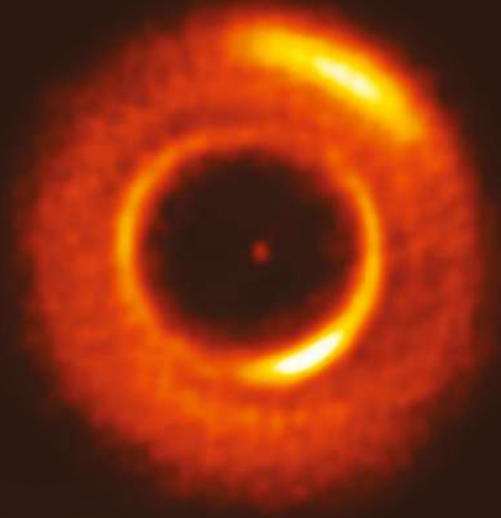
The bleeding rivers of Madagascar

Another snapshot from the International Space Station has returned a wonderful view of the heart of Madagascar. NASA astronaut Ricky Arnold imaged the Betsiboka Estuary, the largest river in Madagascar and the world's fastest-changing coastline, as it bleeds into the ocean. The Madagascan rainforest and coastal mangroves are feeling the full effects of frantic erosion rates as the land becomes cleared. The red water, which is forging its path into the ocean, is cause by the upbringing of red soil from the hillsides and can be accentuated after heavy rainfall.

Docking over Crete

On 29 June, SpaceX launched its 15th resupply mission to the ISS, with all the necessary equipment locked inside one of SpaceX's Dragon capsules. On 2 July the Dragon capsule was pictured almost within touching distance of the space station.

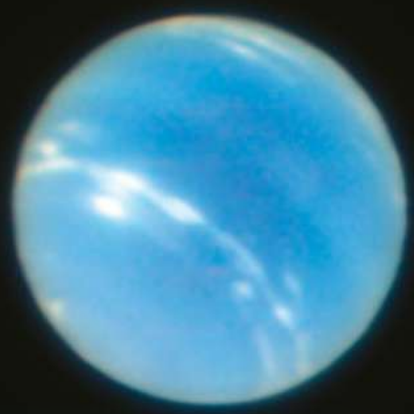
The Dragon capsule is filled with over 2,700 kilograms (5,900 pounds) of living supplies as well as critical materials for more than 250 research investigations. Each resupply mission is as important as the last, and it's good to know it is safely on its way, pictured here floating over Crete, Greece.



The elliptical stellar nursery

Another telescope at the European Southern Observatory is the Atacama Large Millimetre/submillimetre Array (ALMA), which is one of the leading radio telescopes in the world. Using its leading optics that can view celestial objects in a wavelength undiscoverable by our eyes, ALMA was able to look at the baby planetary system of MWC 758.

The image revealed a young star at the centre, along with the first-ever discovery of an elliptical protoplanetary disc with ALMA. This disc is where planets are born, and this image can tell astronomers a lot about the evolution of planets, which can also be compared to our own Solar System.



Neptune in fresh new detail

Neptune, the most distant of the eight planets in the Solar System, is a particularly hard planet to image. Due to it being approximately 4.3 billion kilometres (2.7 billion miles) from Earth, it's just another speck of light in the sky and requires a special telescope to image it.

Step up the European Southern Observatory's (ESO) Very Large Telescope (VLT). Using its Multi-Unit Spectroscopic Explorer (MUSE) instrument, the ice giant was imaged in detail that excels even the Hubble Space Telescope.

Behind the scenes at the VLT

At the Paranal Observatory in northern Chile sits the pinnacle of telescopic optics. The Very Large Telescope (VLT) is the masterpiece of the European Southern Observatory (ESO), and it continues to return truly breathtaking images of the night sky.

The four 8.2-metre (27-foot) telescopes that constitute the VLT are run by an incredibly hard-working crew. Here one of the telescope's innards has been imaged by Vincenzo Forchi. The imaged Unit Telescope is UT1, nicknamed Antu after the indigenous Mapuche's name for the Sun. The other Unit Telescopes are named after the Moon, the Southern Cross and Venus, which are Kueyen, Melipal and Yepun respectively.

Liquid water lake discovered on Mars

The European Space Agency (ESA) has uncovered evidence for an underground pond at the planet's south pole

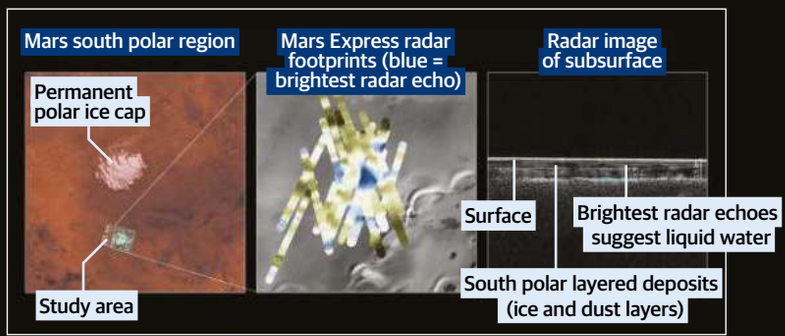
Radar data collected by ESA's Mars Express suggests that, packed between layers of ice and dust, is a body of liquid water spanning some 20 kilometres (12.4 miles) at a depth of 1.5 kilometres (0.9 miles) at Mars' south pole.

Liquid water has been suspected at the base of the polar ice caps for some time, especially given our studies of Earth. After all, it's well-known that the melting point of water decreases under the pressure of an overlying glacier. Moreover, the presence of salts on Mars could further reduce the melting point of water and keep a fluid even at below-freezing temperatures.

It was Mars Express' Mars Advanced Radar for Subsurface and Ionosphere Sounding Instrument, or MARSIS, that made the discovery. However, scientists working on the mission had to develop a series of new techniques to tease a story out of what was originally inconclusive data. "We had to come up with a new operating mode to bypass some onboard processing and trigger a higher sampling rate, thus improving the resolution of the footprint of our dataset; now we see things that simply were not possible before," explains Andrea Cicchetti, MARSIS operations manager. "We'd seen hints of interesting subsurface features for years, but we couldn't reproduce the result from orbit to orbit because the sampling rates and resolution of our data was previously too low."

The finding is somewhat reminiscent of Lake Vostok, discovered some four kilometres (2.5 miles) below the ice in Antarctica on Earth. Some forms of microbial life are known to thrive in Earth's subglacial environments, but could underground pockets of salty, sediment-rich liquid water on Mars also provide a suitable habitat, either now or in the past? Whether life has ever existed on Mars remains an open question, and it's one that Mars missions, including the current European-Russian ExoMars, will continue to explore.

"The long duration of Mars Express, and the exhausting effort made by the radar team to overcome many analytical challenges enabled this much-awaited result, demonstrating that the mission and its payload still have a great science potential," says Dmitri Titov, Mars Express project scientist. "This thrilling discovery is a highlight for planetary science and will contribute to our understanding of the evolution of Mars, the history of water on our neighbour planet and its habitability."



Mars Express has used radar signals bounced through underground layers of ice to find evidence of a pond of water buried below the south polar cap

Test further proves Einstein right yet again

Neutrinos have been found to adhere to the German physicist's 113-year-old theory

Einstein's genius has once again remained intact thanks to a new study using a particle detector constructed at the South Pole. Scientists used the IceCube Neutrino Observatory built beneath Antarctica to examine subatomic particles called neutrinos in a bid to test Einstein's theory of special relativity.

The scientists were specifically testing Lorentz symmetry, which states that an experiment's outcome is not dependent on the velocity and direction of its surroundings, and that the laws of physics remain the same. In this case, they were looking to see if neutrinos – which oscillate between three flavours, electron, muon and tau, as they fly through space – would oscillate at a predictable rate.

The IceCube Lab sits in an icy wasteland of Antarctica at the Amundsen-Scott South Pole Station

Upon interacting with ice neutrinos become muons, which are charged particles heavier than electrons. Since the muons emit light as they pass through ice, scientists are able to take a recording that tracks the trajectory and estimates its energy. This in turn lets them back-calculate the oscillation and energy of the original neutrino. The actual energy spectrum can then be compared to one produced if the violation existed.

In this instance the researchers found no evidence of a Lorentz violation. "People love tests of Einstein's theory," says Janet Conrad, professor of physics at MIT and a lead author on the paper. "I can't tell if people are cheering for him to be right or wrong, but he wins in this one, and that's kind of great. To be able to come up with as versatile a theory as he has done is an incredible thing."

Space agencies prepare for Mercury mission

Teams from ESA and JAXA are getting ready for their first mission to the smallest terrestrial planet in our Solar System

Space engineers in Europe and Japan are currently simulating their forthcoming mission to Mercury ahead of the planned launch in October. By acting as if the BepiColumbo mission is already underway they hope to iron out any potential problems and better equip themselves to deal with all eventualities once the mission's two satellites are sent to space.

To do this, the European Space Agency and the Japan Aerospace Exploration Agency have been using a replica of the spacecraft and computer. Since BepiColumbo's satellites – the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO) – will be close to the Sun, challenges will include the potential overheating of the instruments.

"The failures can be anything," Elsa Montagon, BepiColombo's operations manager, says in a video released by the joint mission. "The failures can be a problem on the spacecraft, a problem on the ground, it can be a problem with computers, a problem with ground software, communication lines, ground stations, control rooms here, it can even be a problem with the operators themselves."

Elsa Montagon is heading a team that will seek to understand more about the origin and evolution of Mercury

Costing more than $1.7 billion, the mission hopes to unravel many of Mercury's mysteries, and will cruise to the planet for seven years. The MMO will study the magnetic field, dust and environment of charged particles surrounding the planet while the MPO will get into a lower orbit to analyse Mercury's surface and interior. Sadly, a lander was scrapped due to budget constraints.

Astronomers find two similar-looking planets

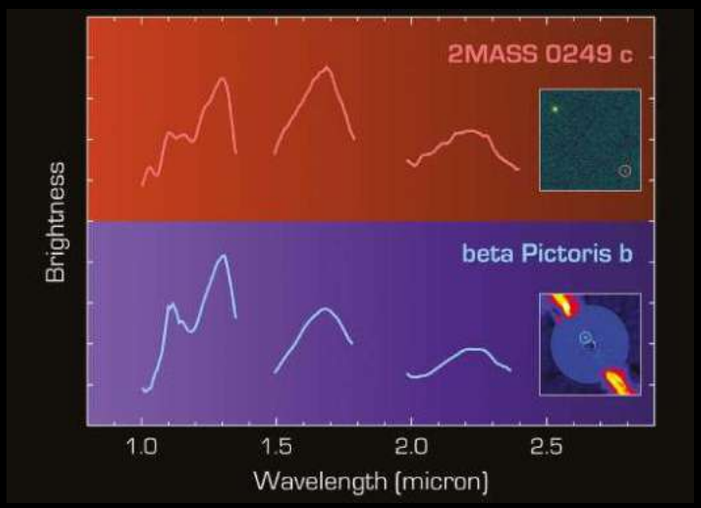
An exoplanet doppelgänger has been discovered for the first time using direct imaging, but the pair's origins are very different

A newfound planet has been getting astronomers excited because it looks remarkably similar to one already well known. The recently discovered 'twin', 2MASS 0249 c, is the same size, brightness and has the same spectrum as beta Pictoris b.

The two planets have been discovered by direct imaging which, up until now, has always uncovered distinct objects. "Finding two exoplanets with almost identical appearances and yet having formed so differently opens a new window for understanding these objects," says Michael Liu, an astronomer at the University of Hawaii and co-author of the new research.

To explain, 2MASS 0249 c orbits a couple of small, faint brown dwarfs some 2,000-times the distance of the Earth to the Sun. Since those dwarfs are not surrounded by a lot of gas or dust, the planet did not form by sucking gas from the star's disc, unlike gas giant beta Pictoris b. Instead, 2MASS 0249 c seems to have formed by directly accumulating gas from the original stellar nursery. It shows there are more ways than one to make exoplanets that look very similar.

"2MASS 0249 c looks like an underweight brown dwarf that formed from the collapse of a gas cloud," says Kaitlin Kratter, astronomer at the University of Arizona. "They're both considered exoplanets, but 2MASS 0249 c illustrates that such a simple classification can obscure a complicated reality."



This graph of the infrared spectra of both planets starkly shows the similarities which are occurring

Pulsars found to turn super magnetic

There could be different stages of a neutron star's life

Radio pulsars and magnetars may not actually be different types of neutron stars. They may be the same kind of star but at different stages of its life, says Tom Prince, a professor of physics at Caltech and a senior research scientist at NASA's Jet Propulsion Laboratory.

The established wisdom since the 1970s is that neutron stars – which form from a large star that has run out of fuel and exploded as a supernova – either become a radio pulsar, in which case it has a strong magnetic field and emits predictable, reliable pulses of radio waves, or turns into a magnetar, and so emits high-energy bursts of X-ray and gamma-ray light.

But evidence continues to show they are a single object, although whether they go from a pulsar to a magnetar or the other way around is open to debate. "It's a bit tricky to observe these restless bodies," says Prince. "Magnetars don't last long – just a year to a few years – before colossal waves of X-rays dissipate the magnetic energy, and pulsars are really quite old by our standards."

Rogue star thought to disturb the outer Solar System

Scientists test the theory that a stellar object may have caused disruption to outer bodies billions of years ago

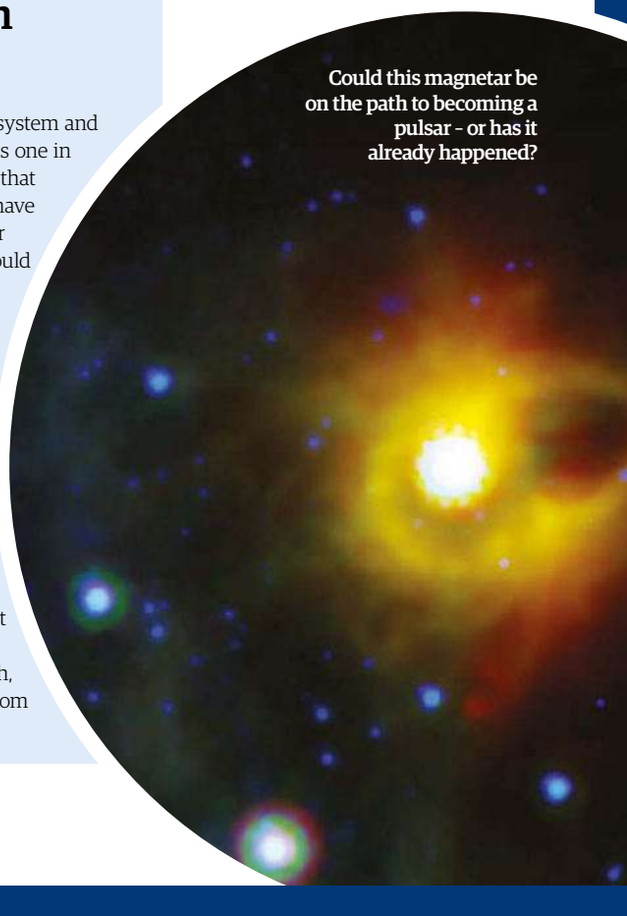
There's a raised possibility that a neighbouring star affected our Solar System, according to a set of simulations led by Susanne Pfalzner at the Max Planck Institute for Radio Astronomy in Bonn, Germany.

They were keen to discover why the outer Solar System has so many anomalies, such as Neptune being larger than Uranus despite being further out and the stretched orbits of small objects such as the dwarf planet Sedna. They worked on the idea that a passing star had disturbed these tiny icy worlds by casting them into interstellar space while causing others to have tilted paths around the Sun.

The simulations of a stellar flyby showed that the possibility of a star grazing past our system and disrupting planets was one in four. They concluded that the event is likely to have happened in our Solar System and that it would have been caused by a star of similar mass to our Sun passing at 80- to 100-times the distance between the Earth and Sun.

This would have happened during the early formation of our Solar System and it would also go some way to explaining why Planet X is likely to be ten-times the size of Earth, despite being so far from the Sun.

An artist's impression of the planet-like object Sedna which was discovered orbiting our Sun at a distance of 8 billion miles in 2003



Could this magnetar be on the path to becoming a pulsar – or has it already happened?

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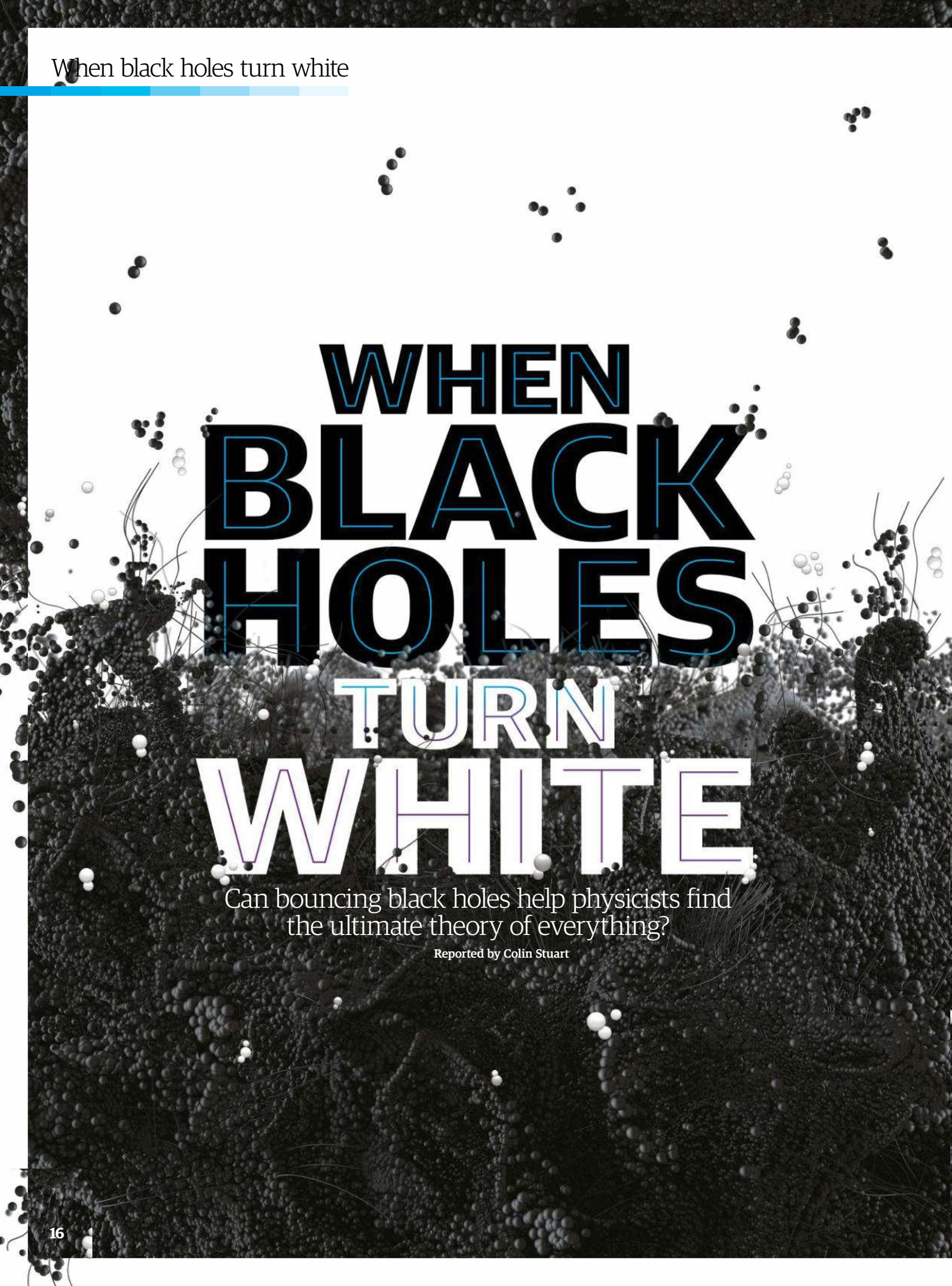


WHEN BLACK HOLES TURN WHITE

Can bouncing black holes help physicists find the ultimate theory of everything?

Reported by Colin Stuart

When black holes turn white

Somewhere out there in the vastness of space lurks a black hole smaller than the full stop at the end of this sentence. Minuscule but mighty, it could hold the key to unlocking some of the greatest mysteries in the universe.

Black holes are the ultimate cosmic laboratory, a way for physicists to test out their theories in an environment so extreme that space and time are curved and warped. Even light cannot resist their eternal grasp, so we see no light reflected from them at all. We can only spot them when their gravity affects something visible or they merge to create gravitational waves. Few places have such a high amount of energy in such a small space.

But what happens if you fall into one? The bad news is you're unlikely to survive the ordeal. The difference in gravity between your feet and your head would eventually get so extreme that it would overcome the forces holding your atoms together. You'd be torn apart into thin strips of human spaghetti, which is where the process gets its whimsical name: spaghettification. Where do your spaghettified atoms ultimately end up? What's at the bottom of a black hole?

What is a white hole?

Black holes are places where you can go in and you can never escape, while a white hole is a place where you can leave but can never go back.

When black holes turn white

Our best answer currently comes from our leading theory of gravity: Einstein's General Theory of Relativity. It tells us that a singularity awaits – an infinitely small, infinitely dense point where space and time cease to be. Hit it and you're immediately erased from existence. Yet if you crush something down much smaller than an atom you enter the arena of quantum physics. At the moment we're yet to take its weird and wonderful rules into account at the bottom of black holes because we have no way of combining it with general relativity. The search for such a theory of 'quantum gravity' is the ultimate goal for many physicists. A Nobel Prize would surely be in the offing for anyone who finds one that accurately describes our universe. It might also help us explain where our cosmos came from because, according to general relativity, the other place you find a singularity is at the moment of creation – the Big Bang – where time and space sprang into existence.

Carlo Rovelli, director of the quantum gravity group at Aix-Marseille University in France, doesn't believe in singularities. "You cannot compress things too much," he says. "It is a universal thing in nature." He argues we need quantum gravity to help explain what happens instead. Rovelli is a founder of one approach to this thorny problem of getting the two theories to play nicely together: loop quantum gravity (LQG). According to Einstein, the fabric of space-time is smooth. However, proponents of LQG suggest that it isn't. "That's not surprising," says Rovelli. "Other things in the universe like light and the energy of electrons come in chunks." He suggests space is not smooth, but grainy – it's also made of tiny little chunks or loops. Think of it like a piece of cloth; at first glance it may seem smooth, but look at it under a microscope and you'll see that it's really made of a series of stitches.

If you apply this logic to the depths of a black hole you get a remarkable result. Occasionally a black hole might 'bounce' into its polar opposite: a white hole. "With a black hole you get sucked in, but with a white hole things can only come out," says Francesca Vidotto from Radboud University in The Netherlands.

Eternal black hole theory
White holes belong in the theory of eternal black holes: interesting concepts that widely assume that matter that enters a black hole is permanently lost and past the point of no return.

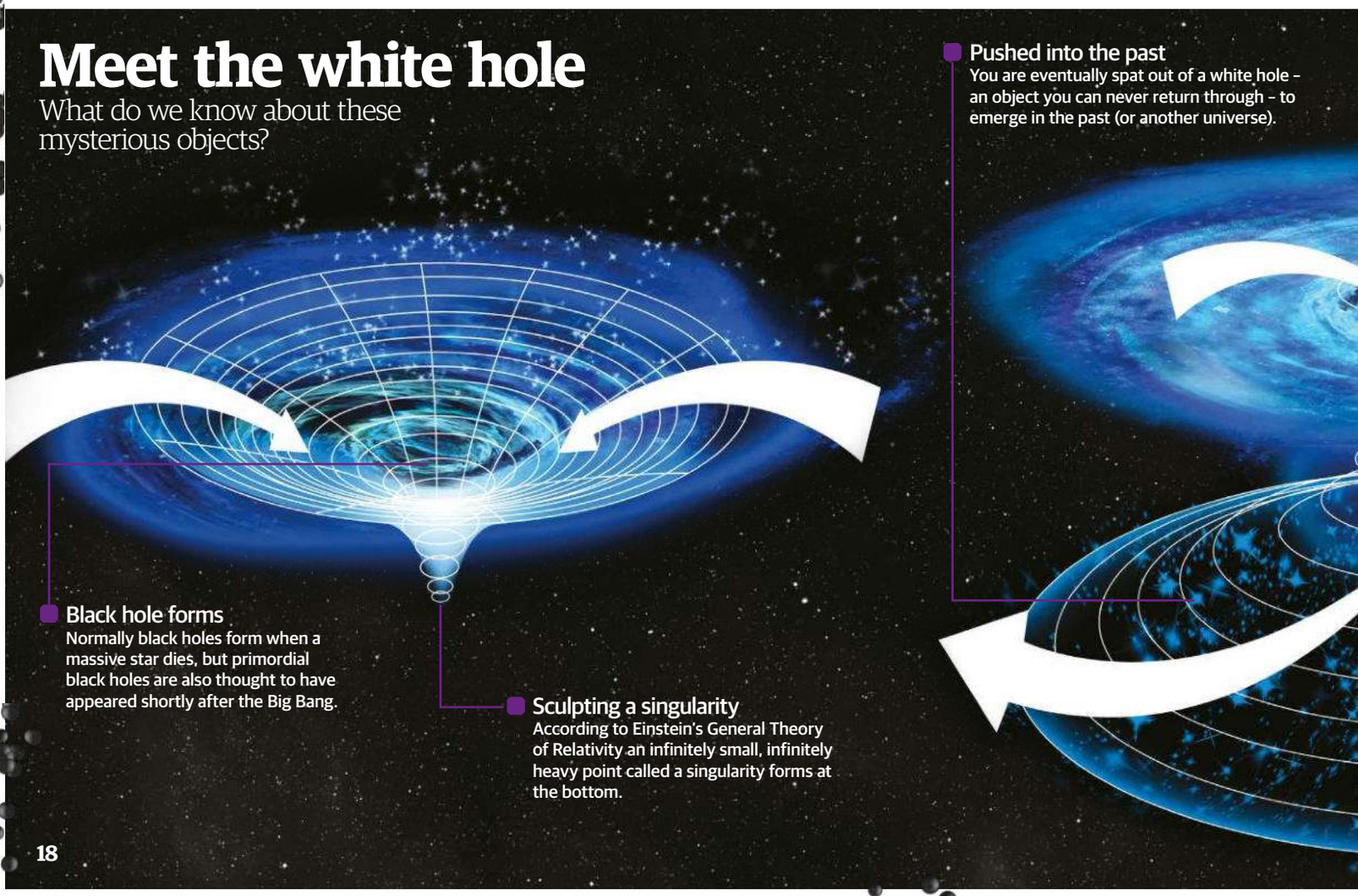
What exactly triggers the change? According to Vidotto it is simple chance. Quantum physics is defined by probability. You can never say exactly where an object is or what state it is in, only where it is more likely to be when you make a measurement. But the smaller an object, the more likely it is for unusual things to happen. Vidotto says an object has a timescale over which it can display these weird quantum properties. "For large objects, like a person or a cat, this time is much larger than the age of the universe," she says. "For a planet-sized black hole it is about the age of the universe." But for a black hole just half a millimetre across you'd expect it to have happened fairly often already across the cosmos. We normally think of black holes as much bigger than that – formed by the deaths of the most massive stars. However, astronomers also imagine there may be primordial black holes out there. Tiny ones formed in the early universe shortly after the Big Bang. Some of those could now be making this odd transition into a white hole.

If that's true we should be able to see evidence of it happening with our telescopes. "You would expect an explosion," says Vidotto. Such a detonation would trigger the rapid release of huge

> "With a black hole you get sucked in, but with a white hole things can only come out" **Francesca Vidotto**

Meet the white hole

What do we know about these mysterious objects?



Black hole forms
Normally black holes form when a massive star dies, but primordial black holes are also thought to have appeared shortly after the Big Bang.

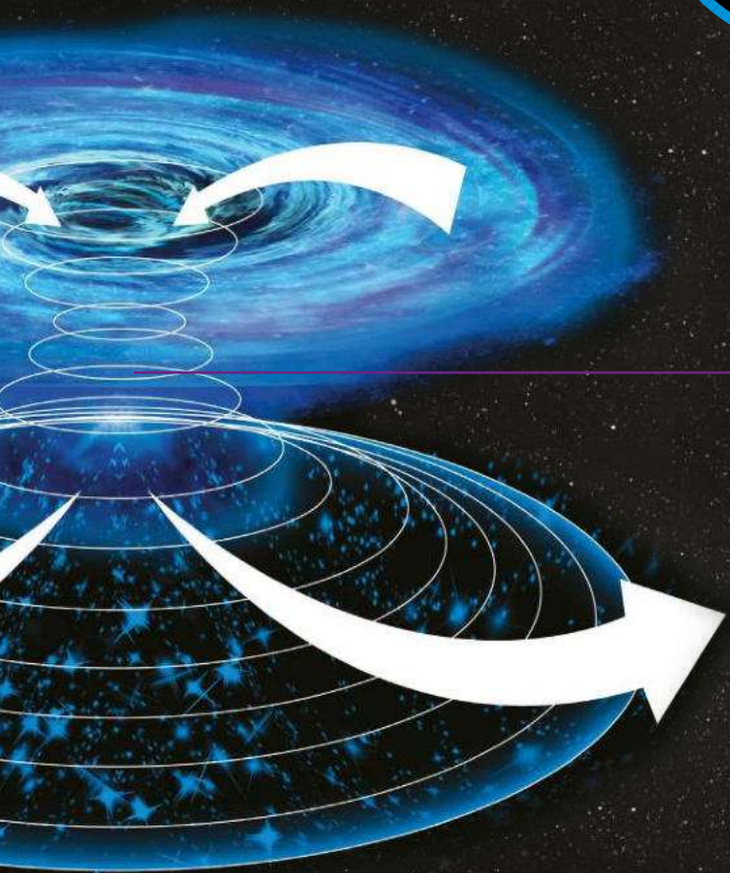
Sculpting a singularity
According to Einstein's General Theory of Relativity an infinitely small, infinitely heavy point called a singularity forms at the bottom.

Pushed into the past
You are eventually spat out of a white hole – an object you can never return through – to emerge in the past (or another universe).

Successors to gamma-ray telescopes like NASA's Swift might detect radiation from black holes bouncing into white holes

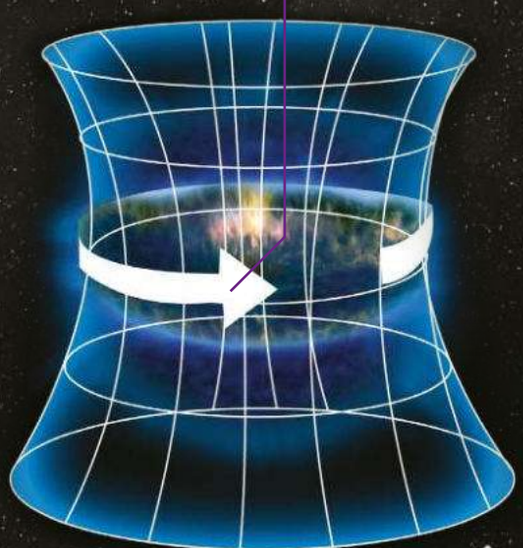
White holes and the Big Bang

An intriguing idea suggested by cosmologists implies that a 'matter-spewing' white hole could be the reason behind the birth of the universe, which we believe was brought about by an event about 13.8 billion years ago known as the Big Bang.



Working a wormhole

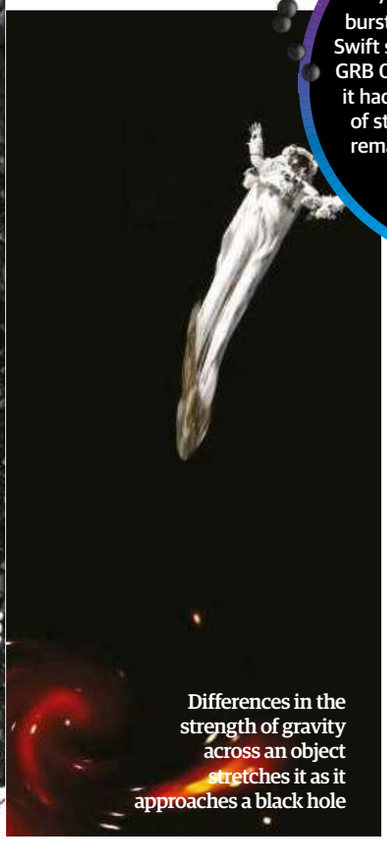
A bridge opens up between the present and the past known as an Einstein-Rosen bridge or, more colloquially, a wormhole.



Spinning singularities

A rotating black hole would form a ring-shaped singularity with a hole in the middle rather than a single point.

White hole candidate
A powerful gamma-ray burst was picked up by NASA's Swift satellite in 2006. Known as GRB 060614, the burst was odd; it hadn't taken place in a region of star formation and lasted a remarkable 102 seconds. Had astronomers found a candidate?



Differences in the strength of gravity across an object stretches it as it approaches a black hole

amounts of energy. How energetic this radiation is depends on the size of the black hole. For black holes the size of your hand or smaller you'd expect it to be the radio part of the spectrum. And over the last decade astronomers have found a handful of unexplained events that might just fit the bill: fast radio bursts (FRBs).

The first was spotted in 2007 and, while there are still many mysteries surrounding them, it is clear they are coming from beyond our galaxy. The nearest emanated from over a billion light years away. Some astronomers have even suggested they might be attempts by aliens to get in contact. Far more likely is that they have some astronomical origin, but what exactly? Perhaps they are generated by colliding black holes or neutron stars. However, there is a way we might be able to prove once and for all that they really are coming from black holes bouncing into white holes.

According to calculations by Rovelli and Vidotto, more distant bursts should have more energy than those nearby. That's because black holes are thought to evaporate over time by releasing Hawking radiation, named after the late physicist Stephen Hawking. Younger black holes in the distant universe should therefore be bigger and release more energy than older black holes closer to us that have had more time to evaporate.

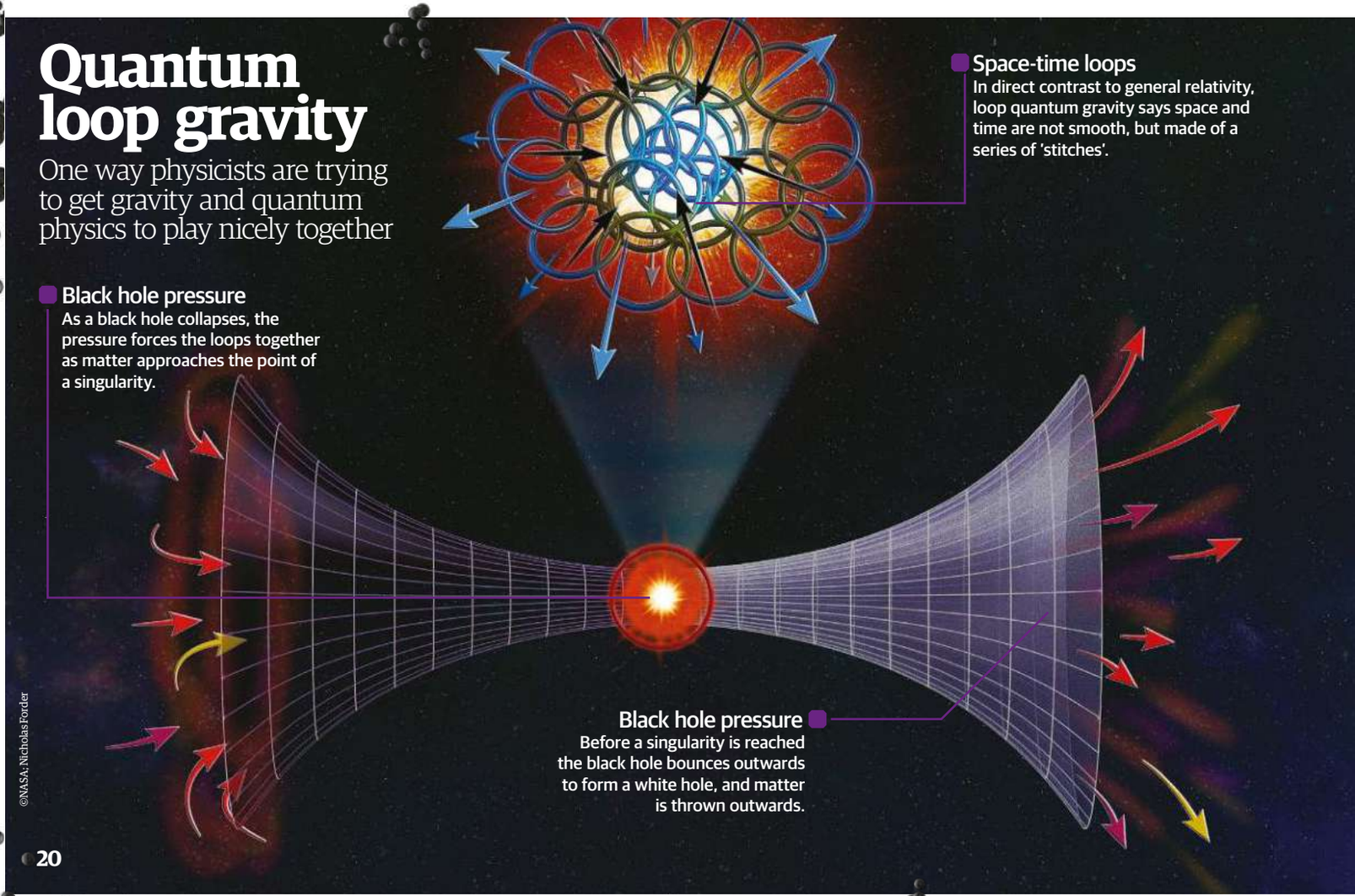
This is in direct contrast to the way things normally work in astronomy. As the universe expands it dilutes the amount of energy in a given amount of space. There's more space between us and a distant object to stretch, so far-away objects have their energy watered down more than those close to us. With bouncing black holes you'd expect the two effects to cancel each other out, meaning these explosive events would have a similar energy across a wide range of cosmic distances. According to Vidotto, observing this behaviour "would be a smoking gun for our theory".

There are some potential snags, however. The FRBs discovered so far are not of the exact energy you would expect from a black hole to white hole bounce. That may not be the end of the world according to Hal Haggard from Bard College in New York. "Given how imprecise the calculations are it's not surprising," he says. "It's in the right ball park." More concerning is that astronomers have identified a repeating fast radio burst called FRB 121102. First discovered in 2012, more than 15 distinct pulses are associated with the same source. "There's nothing in the white hole theory that calls for that," says Haggard. "If more and more of these repeating bursts are found then that goes against this proposal."

He believes the white hole interpretation is extremely speculative, but the pay-off is potentially huge. "It's exciting because there are so few ways

Quantum loop gravity

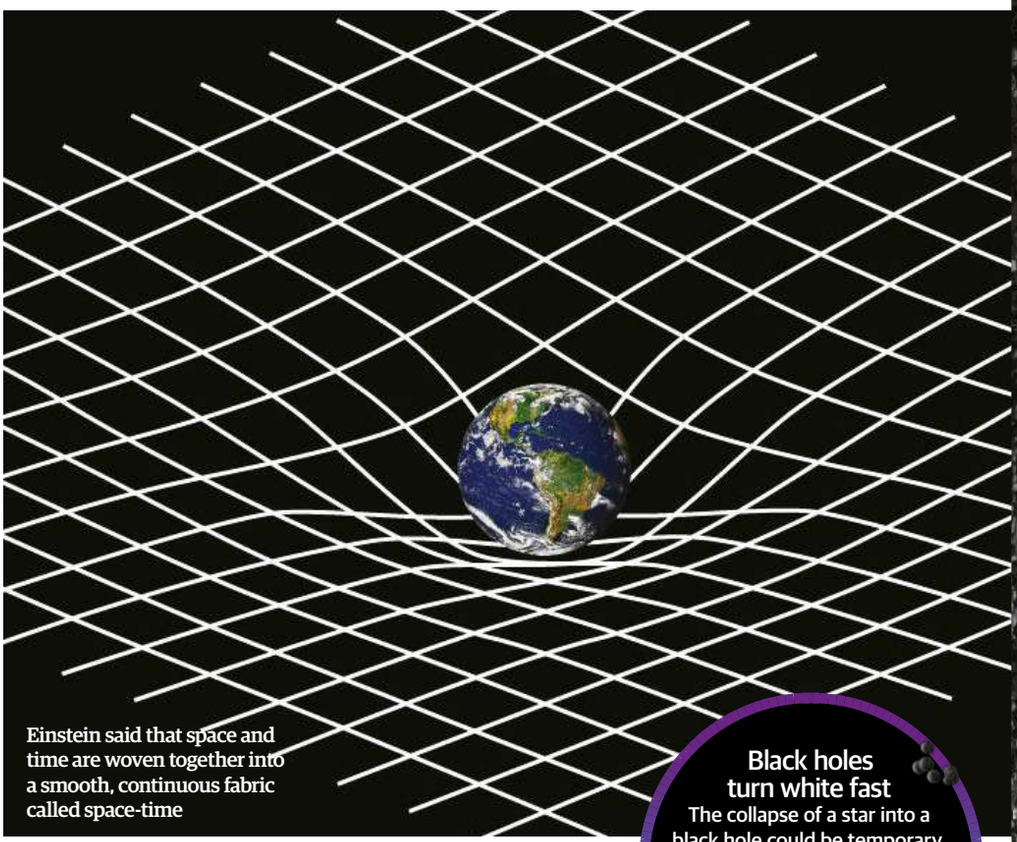
One way physicists are trying to get gravity and quantum physics to play nicely together



to test quantum gravity currently on the table." But confirming a black to white hole transition wouldn't immediately crown loop quantum gravity the victor. Haggard says the approach taken so far is "a generic model that doesn't leverage anything specific about the theory of quantum gravity you're using". However, further detailed observations of how the explosions played out could do the trick. "Detailed analysis of the signals would be able to distinguish between theories, and that's why this is so exciting," says Haggard.

Given the high stakes, fortunately there are other ways a black hole to white hole bounce could show itself. According to Vidotto the explosive event should also generate gamma rays – the highest energy part of the electromagnetic spectrum. Although we do already have gamma-ray telescopes in space peering into the universe, Vidotto says "they are not yet optimised to see in

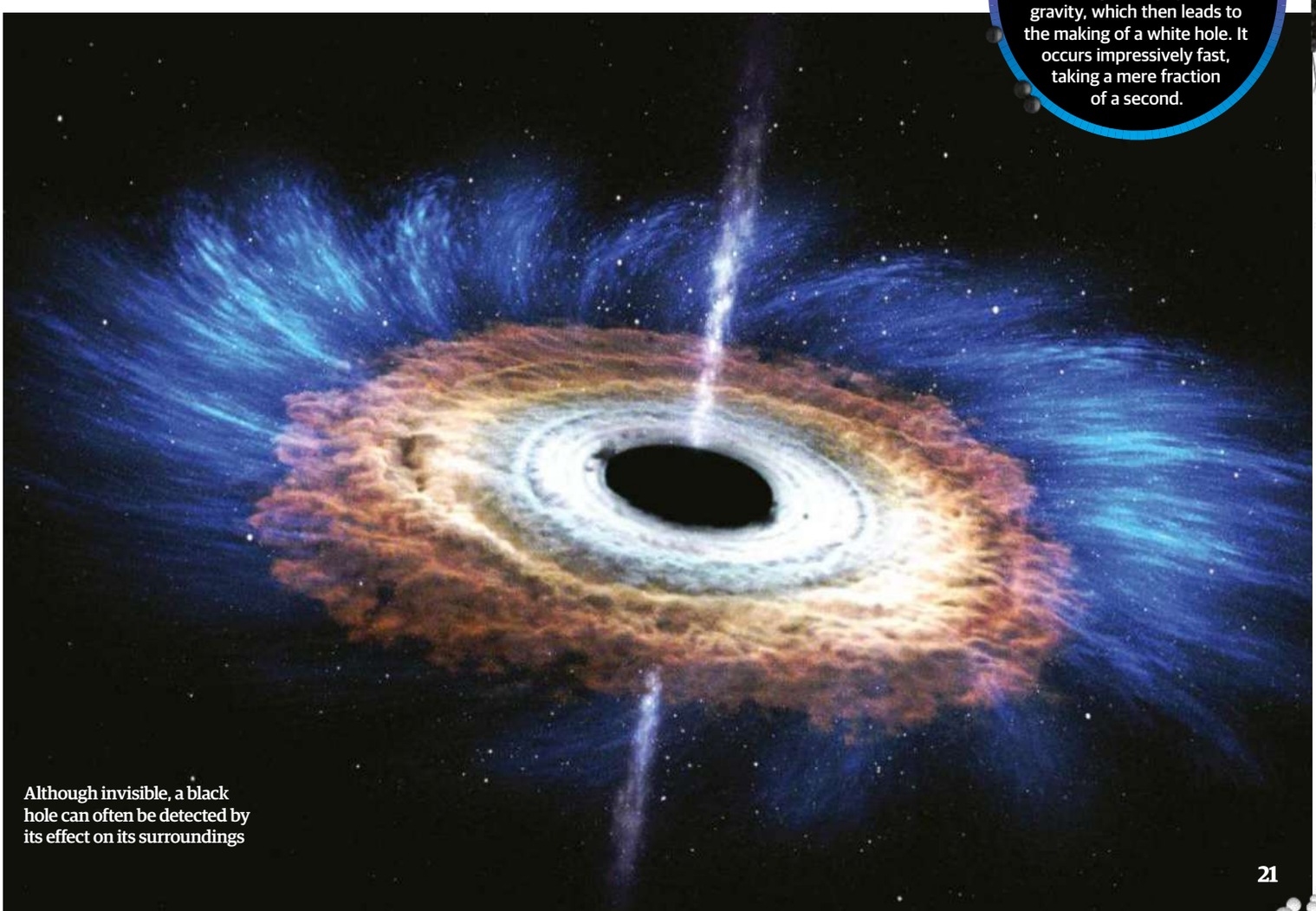
"It's exciting because there are so few ways to test quantum gravity currently" **Hal Haggard**



Einstein said that space and time are woven together into a smooth, continuous fabric called space-time

Black holes turn white fast

The collapse of a star into a black hole could be temporary, according to loop quantum gravity, which then leads to the making of a white hole. It occurs impressively fast, taking a mere fraction of a second.



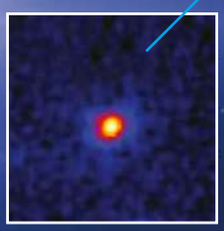
Although invisible, a black hole can often be detected by its effect on its surroundings

Have we already discovered one?

A gamma-ray burst from 2006 could be our first sighting

A possible white hole?

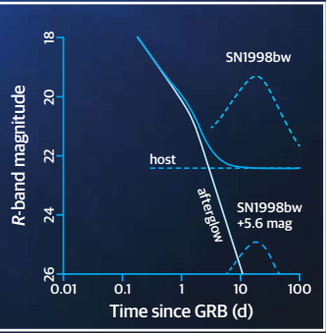
Back in June 2006, the Swift satellite captured a burst of gamma rays. Since no supernova was seen following the event, astronomers realised that they had come across a possible new object. In 2011 it was hypothesised that the burst was a white hole.



Mission Profile:
The Neil Gehrels Swift Observatory
Launched: November 2004
Operator: NASA
Launch vehicle: Delta 7320
Orbit: Low-Earth

Possible origins

GRB 060614 has behaviours of both long and short bursts, leaving astronomers to believe that its birth occurred unusually. The burst sits in a galaxy with very few stars that could produce either an exploding star or a long burst.



"What is remarkable is that no new physics is needed. No strings, no new forces and no new particles" **Carlo Rovelli**

such high-energy gamma rays". Future gamma-ray observatories may well be up to the task, however. In the meantime there's a third way in: synchrotron emission. Particles like electrons would be accelerated through strong magnetic fields during the high-energy explosion, emitting radiation as they do so. "The challenge is how can we distinguish these cosmic rays from all the other sources in the sky," says Vidotto.

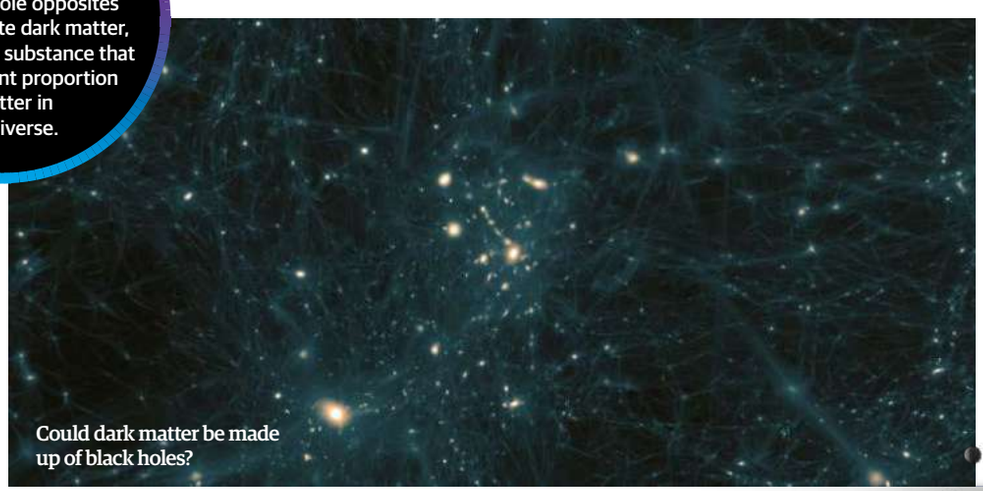
If any one of these endeavours is ultimately successful, confirming a black hole to white hole transition won't just help with the mystery of quantum gravity. It could also tackle an equally perplexing puzzle currently frustrating astronomers: dark matter. When we look at galaxies and clusters of galaxies there appears to be far more gravity than can be accounted for using visible material like stars and gas alone. Instead astronomers have suggested there is some hidden material skulking in the shadows which acts like a galactic glue, helping bind galaxies together with its own gravitational pull. The most fashionable contender for this dark matter has been supersymmetry – the idea that alongside the familiar sub-atomic particles like electrons and protons there are bigger particles that are their mirror images. The lightest of these supersymmetric particles has been the go-to explanation for dark matter for well over a decade. Despite a lot of searching, no one has ever found a supersymmetric particle.

That's causing some physicists to look elsewhere for an explanation. Rovelli believes the remnants left behind as a black hole transitions into a white hole could go some way to providing the missing gravity. Being so small, they would be hard to detect other than by their collective gravitational pull. "What is remarkable is that no new physics is needed. No strings, no new forces and no new particles," Rovelli says, referring to string theory – an alternative way to attack the problem of quantum gravity. Haggard agrees it's possible that "they could make up a substantial fraction of dark matter". He also says that "dark matter may not be one thing – it may be a mixture of particles we haven't discovered and something else". That something else could be black holes turning white.

For now astronomers are left in a tantalising position. Through fast radio bursts we might not only have the first clues that black holes can morph into their polar opposites, but also a way to tackle the ultimate questions about the nature of space and time itself. Then again, we may not. Only more observations with more telescopes from one end of the electromagnetic spectrum to other will tell us whether to call the Nobel committee or return to the drawing board. The stakes couldn't be higher.

Secret ingredient to dark matter

According to recent research, these black hole opposites could constitute dark matter, the mysterious substance that forms a decent proportion of matter in the universe.

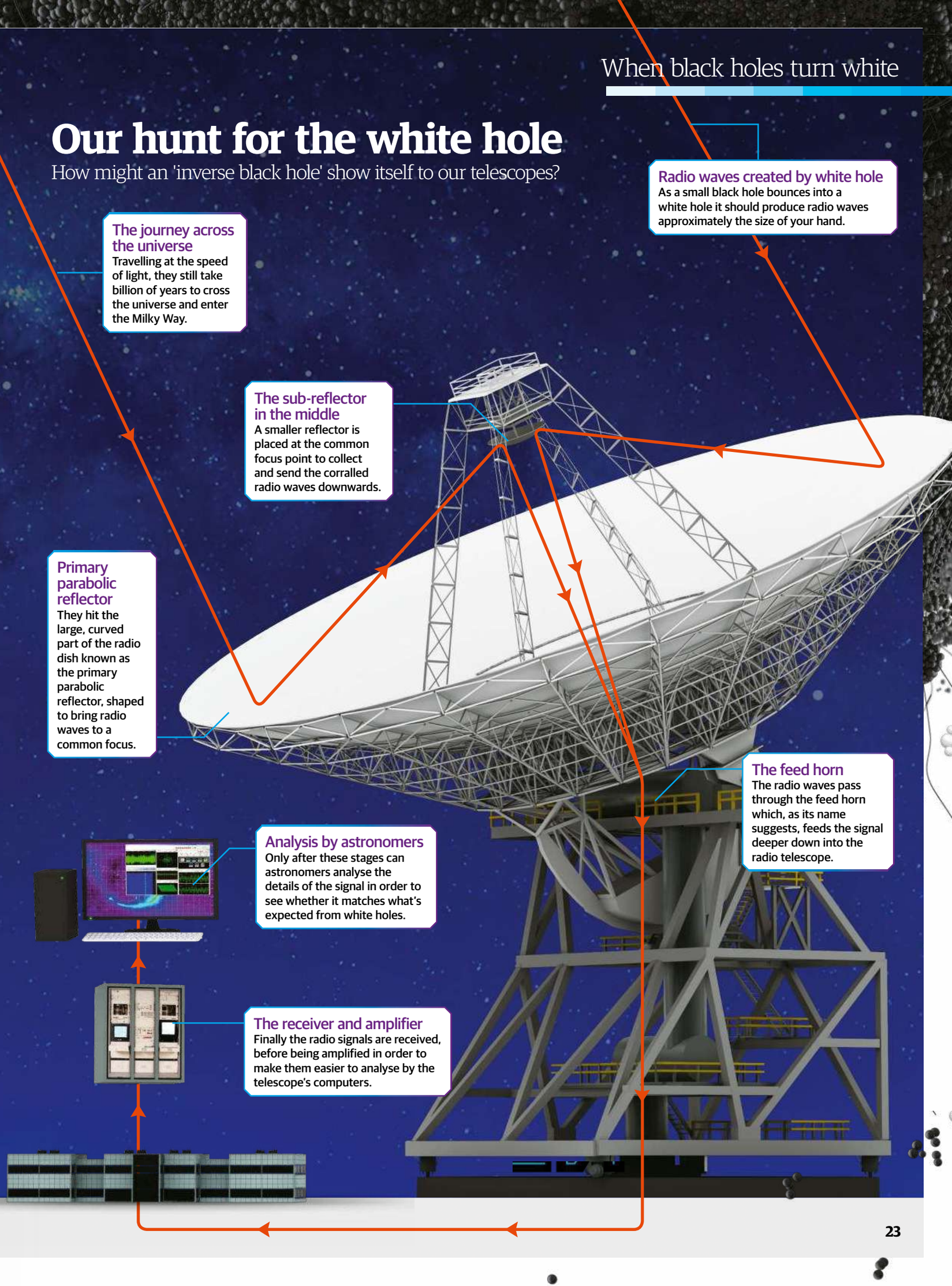


Could dark matter be made up of black holes?

©Adrian Mann;

Our hunt for the white hole

How might an 'inverse black hole' show itself to our telescopes?



Radio waves created by white hole

As a small black hole bounces into a white hole it should produce radio waves approximately the size of your hand.

The journey across the universe

Travelling at the speed of light, they still take billion of years to cross the universe and enter the Milky Way.

The sub-reflector in the middle

A smaller reflector is placed at the common focus point to collect and send the corralled radio waves downwards.

Primary parabolic reflector

They hit the large, curved part of the radio dish known as the primary parabolic reflector, shaped to bring radio waves to a common focus.

The feed horn

The radio waves pass through the feed horn which, as its name suggests, feeds the signal deeper down into the radio telescope.

Analysis by astronomers

Only after these stages can astronomers analyse the details of the signal in order to see whether it matches what's expected from white holes.

The receiver and amplifier

Finally the radio signals are received, before being amplified in order to make them easier to analyse by the telescope's computers.

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INTERVIEW BIO

Nick Sagan

As the son of acclaimed astronomer and science populariser Carl Sagan, it was always inevitable that Nick Sagan would have a strong link to space. Aged just six he recorded a greeting for the Golden Record placed aboard both Voyager spacecraft in 1977, should intelligent life come across it they'd hear: "Hello from the children of planet Earth." As an adult he has written books and screenplays, developed videogames and produced TV specials, most of which are strongly associated with science fiction. His sci-fi novels include *Idlewild*, *Edenborn* and *Everfree*.

CARL SAGAN EXCLUSIVE

"My father had a huge impact on my life"

Although Nick Sagan did not follow in the footsteps of his father, astronomer Carl Sagan, his novels, TV shows, movies and videogames have clearly been influenced by his love of space

As a child, were you aware that you had a famous father?
Well, there were certain signs that were hard to ignore. When I was in elementary school they would show episodes of *Cosmos* in both my science and social studies classes, and I would sit there watching my dad talking to us on TV. I also had a very nice, if strange, upbringing where scientists and science-fiction writers would come to the house and we'd go to rocket launches and all that kind of stuff. But none of this seemed peculiar to me and it just seemed to be what the family did. It was only later when I realised my upbringing was surreal. At the time it was perfectly normal.

Would your father try to engage with you about space and, if so, were you actually interested?
I was fascinated, but then I should say that I was also rather spoiled because my dad was one of the greatest teachers ever. He was so giving of his time and truthful. Whereas a lot of parents who get a question they don't know may try and fudge something to make it sound plausible or say, "I don't know kid, go look it up," he would be honest. If there was something he didn't know the answer to – which I have to say was rare – then he'd say, "that is a great question and maybe you'll be the first to discover the answer". That was very sweet, loving and honourable.

Nick made *Alien Encounters* in cooperation with the SETI Institute, which was founded by his father in the early 1960s

At the age of six you recorded a greeting that was placed aboard NASA's Voyager Golden Record. Do you recall making that recording?
I do recall it. I remember being plopped in front of a microphone and being told to say what I wanted to communicate to aliens if they happened to exist, and "Hello from the children of Planet Earth" is what came to mind. It seemed interesting, fun and fascinating, but also very normal.

It was only in later years that I looked back and saw how astonishing the Voyager mission was and began to appreciate the amazing feat of exploring outer planets and getting a close look for the first time. I just think there is a message from me on board the farthest human-made object in the universe and it's fleeing us as quickly as it can and never coming back. It conjures a whole range of emotions of pride, humility, awe and wistfulness.

So it's fair to say that your father has had a massive impact on your life?
Absolutely. My dad was a scientist and my mother a writer and I have taken the professions of both parents and kind of weaved them together in some way. But also, when I was a kid my dad introduced me to some of the grandmasters of science fiction, such as Edgar Rice Burroughs. He read the *A Princess of Mars* series as a child and I just devoured those little paperbacks as a kid. I'm sure that had a major effect on me too.

What made you decide to pursue a career in Hollywood?
I was in Los Angeles as an angst-ridden teen and I wasn't sure what I wanted do, but I had an epiphany in a video store. A friend suggested I try a British series from the 1960s called *The Prisoner*,

Two phonograph records containing sounds from Earth – including a message from Nick Sagan, aged six – were put on board the Voyager spacecraft

which was a really strange but groundbreaking programme, and I remember taking it home and watching it. My mother likes to say that when I came out of my room there was this nimbus of light around me, but that's because I knew at that point what I wanted to do. I realised it was possible to create something that was not only entertaining, but functioned on a social, political and even religious level. I also saw that you can portray your soul in a creative, subversive piece. I was really inspired, especially so because Patrick McGoohan had created, written, directed and starred in the series, making these amazing creative contributions.

What did you do next?

Well, I went on to take my California High School Proficiency Exam, which is like the equivalent of a high school diploma, and I enrolled in the Santa Monica College before transferring to UCLA Film School. The scriptwriting chairman Richard Walter was impressed with a script I wrote and sent it to an agent who also read and loved it. It was then optioned by a production company and I was hired to adapt a science-fiction novel into a screenplay. Suddenly, I was a working Hollywood screenwriter.

Had you ever considered following your father in exploring astronomy or science?

I did, but science is challenging. So while I love it and I love the humility at the heart of the scientific method, my brain doesn't necessarily bend that way. I was thrilled to get an A in a college astronomy class – that was by far my top achievement there – but I admire and to a certain extent envy people who have the minds that allow them that kind of path. So no, I've never seen myself following in his footsteps. It would be like trying to be a successful baseball player when your father is Babe Ruth: how do you top that? I like this combination I pursue where I take the big questions behind a lot of the science that he did and explore them in different ways.

So you never felt a weight of expectation?

To his credit, my dad never pushed me into astronomy at any point. He just wanted me to find my own path and be happy and productive, and I never felt pressured to become a scientist. I'm very grateful for that.

You pitched ideas to the *Star Trek* writing team and ended up working on some of the episodes. Was your interest in science fiction sparked by being surrounded by science fact?

Well, I'm sure that it was a mix of things, but there are also different kinds of science fiction. Hard sci-fi is scientific and it'd look at how a warp engine might work or explore the physics of time travel. Social science fiction raises significant questions about humanity and our species: how did we get started, where are we going, what's it all about, do we carry the seeds of our own destruction within us and so on. That's where my heart lies. So while I was influenced by my dad's planetary science, I think I was just as much, if not more influenced by the science-fiction writers he introduced me to. I also grew up watching the original *Star Trek* and fell in love with those episodes.

As well as working for the screen, you co-wrote a book that looked at how science fiction had impacted on real-life technologies and ideas. How did that come about?

I think there's a wonderful reciprocal relationship between science and science fiction that doesn't get talked about quite as much as it should. Quite often a scientist will create something

"It was only in later years that I looked back and saw how astonishing the Voyager mission was and began to appreciate the amazing feat of exploring outer planets"

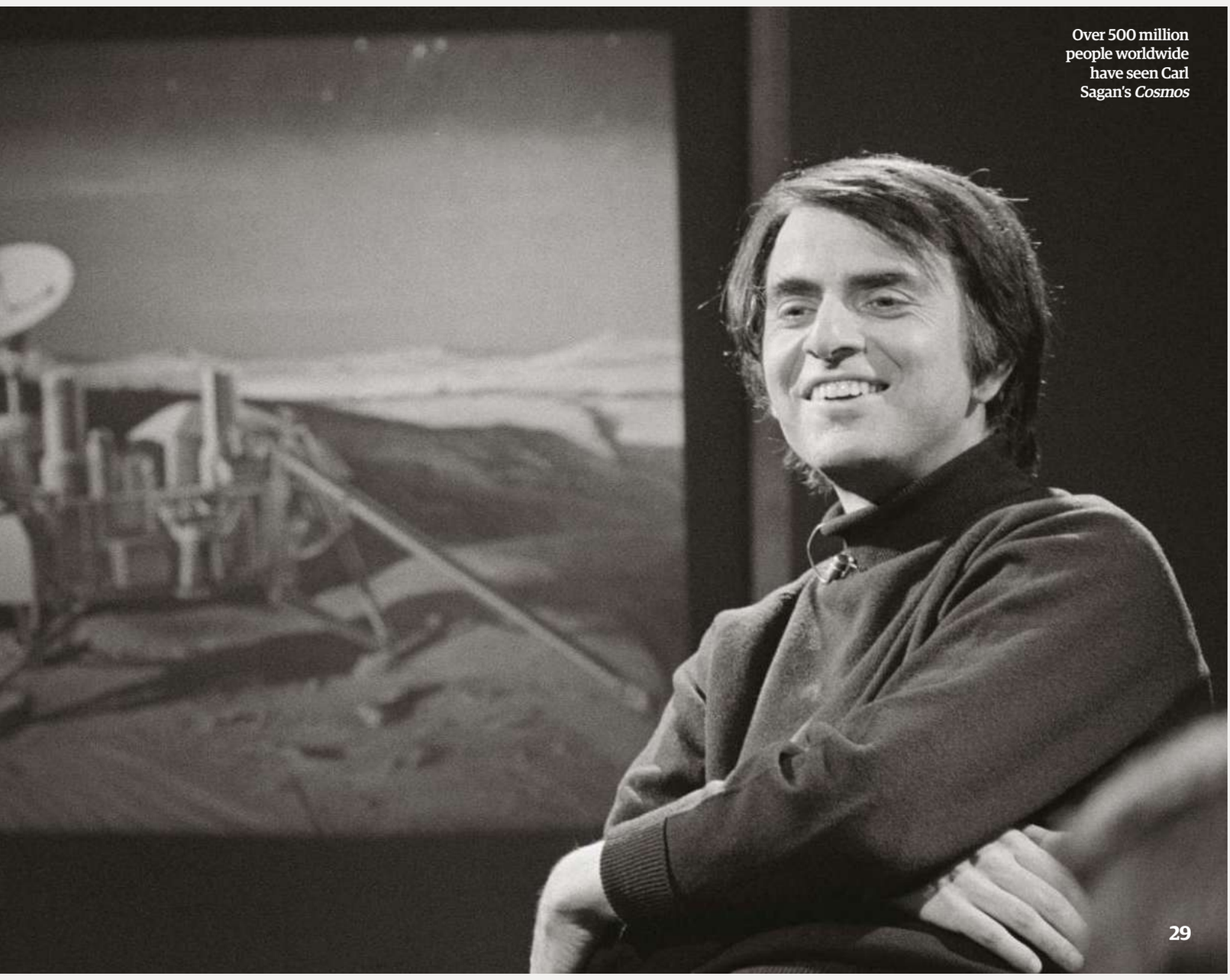
or advance some area of knowledge that science-fiction writers will take inspiration from, and that in turn would inspire other scientists.

There are people out there designing robots who were originally inspired by R2-D2 and C-3PO, for example, and if you go back in time you'll find the father of modern rocketry Robert H. Goddard and see that he had previously sent fan letters to H.G. Wells about how much he loved *War of the Worlds*, talking about how we would actually get to Mars and all of this kind of stuff. So you see this really fascinating and wonderful relation that serves a useful purpose in society where fact and fiction work hand in hand to either imagine a better future, or at least warn against the consequences of where we might go if we're not careful.

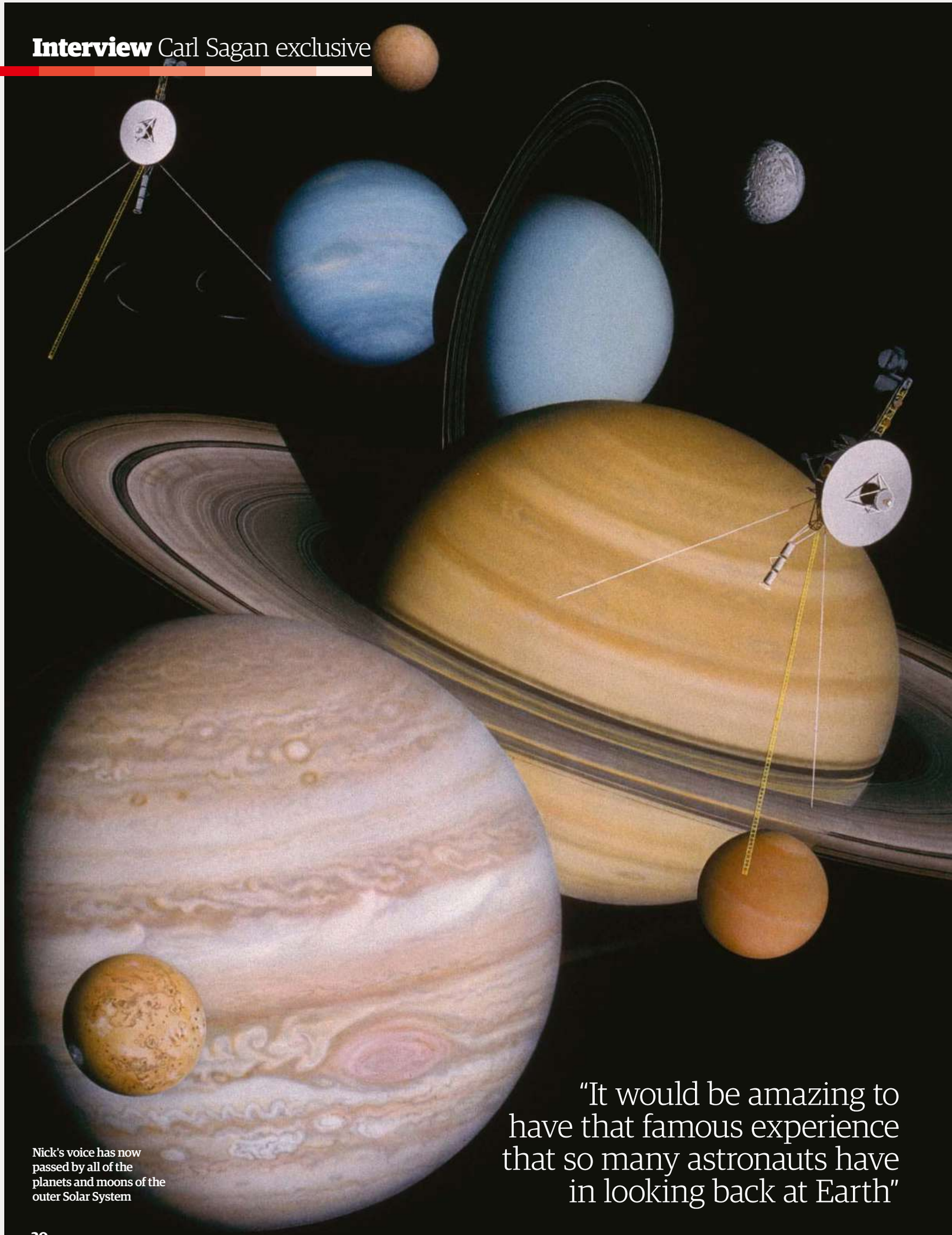
Is that blurred line of interest one of the reasons why your two-part *Alien Encounters* series mixed science-fiction drama with commentary from scientists such as Neil deGrasse Tyson?
It is tricky because you do get people who feel like we're mixing things that shouldn't be mixed, but at the same time there's a real opportunity to do something fascinating. With *Alien Encounters* for the Discovery Science network we were able to present a fictional scenario and then have scientists talk about the possibility of it happening, what it would mean and the larger questions. I think it worked well, and I don't think anyone was confused about it.

Was it the same approach for *The Searcher* which was shown at the Adler Planetarium in 2011?
Yes, and that was particularly meaningful to me because my dad went to the University of Chicago so the idea of creating a show for a planetarium that he had visited many, many times as a college student resonated. This story involved an extraterrestrial who effectively commandeers a planetarium show and leads us on an adventure looking for his lost people.

We visited different astronomical phenomena along the way, and I found the planetarium to be a nice engine to take us to those wonderful places. But what we also felt was that there were certain things that were scientific fact that planetarium show viewers might have thought was science fiction. For example, there is a whole segment on colliding galaxies and how the Andromeda Galaxy is going to collide with the

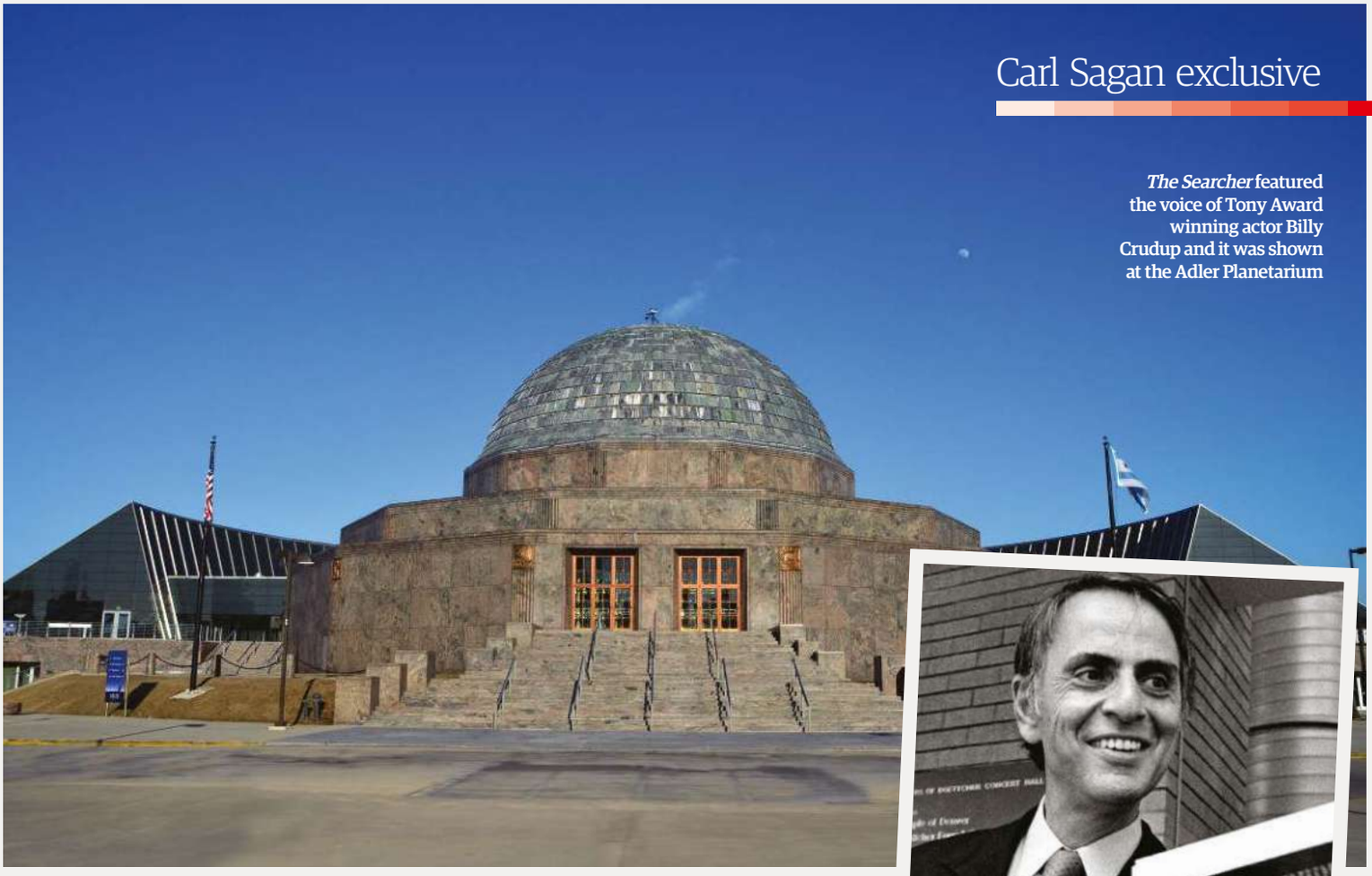


Over 500 million people worldwide have seen Carl Sagan's *Cosmos*



"It would be amazing to have that famous experience that so many astronauts have in looking back at Earth"

Nick's voice has now passed by all of the planets and moons of the outer Solar System



The Searcher **featured the voice of Tony Award winning actor Billy Crudup and it was shown at the Adler Planetarium**

Milky Way at some point in the distant future and people thought that it was fiction. When you're blurring the lines, you need to make sure people understand what's real and what's not.

Given your work involving aliens, does the potential for life elsewhere fascinate you?
Well, it is, of course, one of the biggest questions we can think to ask, and it goes back to the very heart of our origin. What I find fascinating is that my dad, back in the 1960s, put out a possibility that there might be life in the clouds of a planet as inhospitable as Venus. And in the past few months there have been advances in science suggesting that it actually might be a realistic possibility, with scientists saying we should check the clouds to see if it's true. It is staggering to me that in all these years after his death he continues to be involved at some level in the search for life.

Do you keep up to date with the efforts to find extraterrestrial life?
Absolutely. I'm fascinated by the idea of panspermia and the potential that life on Earth could have originally come from the ice of the comets that impacted our planet, but I'm also interested in what this would mean: we'd learn so much more about our story if we could find that we're not alone. I'm also intrigued by the Drake equation; the suggestion that the universe should be teeming with life.

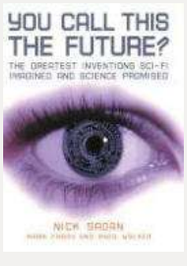
I have a deep, lonely, longing feeling about such matters and I very often wonder if the reason we haven't found extraterrestrial life is because intelligence evolves to the point where it takes over a planet, only for the same skills to work against a species. Do species simply blow themselves up when they get increasingly powerful technology and is that why we haven't heard from anyone out there? If that's the case, then what a lesson that is for us to be careful. But then as my dad would also say, if we are in a strange, unlikely scenario where we're unique, then it makes it even more important for us to treat each other with great kindness and reverence. Don't harm a human because there's a chance you won't find another one anywhere else in the universe.

When you look at the possibilities today, such as space travel, it is an exciting time?
Absolutely. If we don't blow ourselves up then we're at the dawn of an amazing new era where theoretically we could begin to not only dip our toes in the vast cosmic ocean, but start to truly reach out to species. I remember Stephen Hawking was talking about the need for us to establish an off-world colony ideally within the next hundred years, the idea being that we should not keep all of our eggs in one basket and instead take an opportunity to safeguard the species by having people in different places. I find something deeply poignant about that. There's this amazing universe here and we're just now discovering the ability to practically reach out. Soon we will be able to figure out how to either terraform or set up a long-lasting future and live on a previously uninhabitable world.

Is that desirable?
Well, at the same time it's unlikely that we're going to find anywhere else in the universe that's more suited for life on Earth than Earth. We've evolved to enjoy this planet and, as much as the excitement over the possibility of space travel appeals to me and appeals to many people, I think it is a huge mistake to ever view Earth as some kind of disposable starting point. It may well be that we'll have to fan out and find new digs, but we really need to appreciate where we started.

Both Carl and Nick have written several science-based works

Would you be interested in going to space?
I missed my window. I'm 47 now and I'm not sure I'd pass the astronaut fitness candidacy. But having said that, yes, as an intellectual exercise I would love to go. It would be amazing to have that famous experience that so many astronauts have in looking back at Earth and seeing the planet outside of yourself. People who have done this talk about this amazing spiritual feeling that passes through them and just for that reason alone I would love to go. I'd also like to experience life on a space station. It's something I've always thought about and wondered what it would be like.



You Call This The Future? **examined 50 of the most popular futuristic intentions thought up by science-fiction writers**

WHAT WAS THAT SPACE EXPLOSION?

Astronomers recently observed a flash in the night sky 100-times brighter than a supernova, sparking huge interest across the world. **All About Space** speaks to the team to uncover what it could have been

Space explosion

On a hot June day in Northern Ireland, a team of diligent young scientists were looking over a bunch of images taken from a twin-telescope system based in Hawaii. There was nothing inherently unusual about this. The students and post-doctoral researchers within the Astrophysics Research Centre at Queen's University Belfast have long followed a set routine, one that has already seen them spot a fair few transient astronomical events. But this day was different, and it would make headline news not only in the specialist press, but mainstream newspapers around the world.

The task was straightforward enough, simply entailing the scanning of the sky every couple of nights using the Asteroid Terrestrial-impact Last Alert System, or ATLAS, before checking the resulting imaging data. "We'd go back and view the same area that we'd already looked at to see if something had changed," explains Dr Kate Maguire of the tried-and-tested process. "And on this occasion there was something that made us very excited very quickly."

That something was indeed extraordinary, and it was duly noted by Peter Clark, a PhD student who was on duty that week. He'd noticed a new object suddenly appearing in the night sky on 16 June. "It had not been there a couple of days before," says Maguire, "so it was clear that it had just popped up." This meant the observation was being imaged soon after an explosion, but it would prove to be a far more unusual discovery than that.

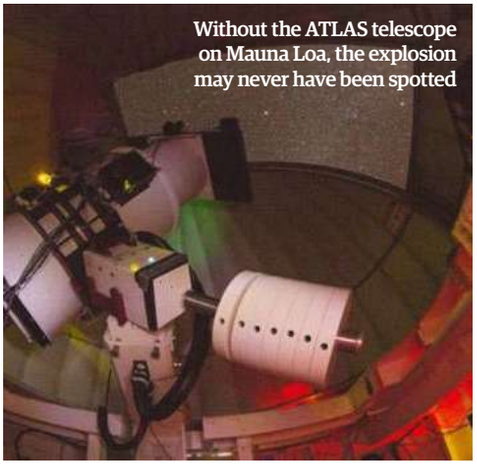
At first, Maguire says the Belfast team considered it to be a cataclysmic variable star – a binary system consisting of a white dwarf primary star and a mass-transferring secondary that would irregularly increase in brightness before dropping.

"The object rose so quickly and so fast that it certainly looked like a variable star in our galaxy, so we said, 'oh okay, it most likely is'," she explains. "But we now know it's not a variable star in our galaxy." That's because scores of astronomers got in on the act and kick-started scores of fact-finding missions. "Everyone threw their telescopes at it," Maguire says. In that sense, it literally became the hottest of properties.

To discover more about the object, the research team had reported their findings to *The Astronomer's Telegram* on 17 June, alerting other scientists to this glowering phenomenon in the sky. "We generally wanted to take a spectrum of it to try and understand it better and figure out what elements are present," says Maguire. "We did that pretty quickly and it looked really weird."

Many astronomers began to devise and test their own theories. "My immediate thought was that it could be some kind of nearby explosion, like a nova, within our own galaxy – that is, less than 30,000 light years away," says Professor Robert Rutledge, founder and editor-in-chief of *The Astronomer's Telegram*, which is an internet-based, short-notice publication that allows scientists to disseminate information on fresh astronomical observations.

The object certainly displayed some odd characteristics. For starters, the cosmic explosion appeared to be between 10- and 100-times brighter than an ordinary Type Ia exploding star, or supernova. It was also observed to reach peak brightness in just three days, even though most supernovae take weeks to get to such a point.



Without the ATLAS telescope on Mauna Loa, the explosion may never have been spotted

> "My immediate thought was that it could be some kind of nearby explosion, like a nova, within our own galaxy" **Robert Rutledge**

The Astrophysics Research Centre at Queen's University Belfast was the first to spot the explosion

Other explosions in space

Flashes of light are constantly lighting up the universe, but what causes them?

Type Ia

1. Attracting matter
Type Ia supernovae occur in binary systems where one star is a primary white dwarf. The high density and intense gravity of the white dwarf pulls matter from the companion star.

2. Building up
At a certain point called the Chandrasekhar limit, which is the moment the white dwarf reaches approximately 1.4 solar masses, a nuclear chain reaction starts.

3. There it blows
The belt detonates and the white dwarf explodes, turning the white dwarf into a supernova. They also blow at that precise ratio, making them predictable.

4. Bright lights
The resulting light is so great that it is 5 billion times-brighter than the Sun. They blaze with equal brightness at their peaks.

Type II

1. Large stars
Having fused numerous elements from hydrogen to helium, a star with at least eight-times the mass of the Sun ends up with a core of iron and nickel.

2. Beginning of the end
At this stage there is no hope for the star since the core is no longer able to fuse any elements.

3. Crushed by its own mass
Unable to balance out the gravitation pressure of the star's own mass, the core contracts under great force, putting it under grave pressure.

4. Core collapses
After the core collapses in on itself, it rebounds. This sequence of implosion-explosion results in a Type II supernova, releasing outer layers of gas.

Gamma-ray burst

1. Close to death
The energy of a massive star fades towards the end of its life, causing it to swell and become a red giant.

2. Collapsing under gravity
The star collapses under gravity once the fuel supply runs out, and the core is crushed into a black hole.

3. Creation of a supernova
As intense heat forces particles out from the core, they slam into the outer layers of the star.

4. Flash of gamma rays
When the matter falls into the spinning black hole, a radiation blast across the black hole's axis of rotation produces a burst of high-energy gamma rays.

ATLAS

The telescope that saw it all

ATLAS is actually designed to detect near-Earth objects before they smash into our planet

Two locations

ATLAS – or the Asteroid Terrestrial-impact Last Alert System – is located at two sites: Haleakala and Mauna Loa. The telescopes are 160 kilometres (100 miles) apart.

Advanced warning

The telescope is designed to provide a day's warning for a 30-kiloton asteroid (which could wipe out a town) and three weeks for a 100-megaton one (a country killer).

The lens

Each equatorially mounted telescope is a 0.5-metre diameter f/2 Wright-Schmidt system and it is fitted with a 110-megapixel CCD array camera.

Two telescopes

Having two separated telescopes allows astronomers to receive extra information about an asteroid by the parallax effect, allowing for more accurate calculations about its orbit.

Good vision

According to ATLAS, the scans of the sky can pick up stars of magnitude 20, which it says is the equivalent of spotting the light of a match flame in New York from San Francisco – a distance of over 4,000 kilometres (2,585 miles).

Field of view

It has a large 7.4-degree field of view which is about 15-times the diameter of the full Moon. Each can survey a quarter of the whole observable sky four times per clear night.

Processing images

It is capable of gathering 1,000 images per night on each site, and during that time it can potentially detect as many as 75,000 asteroids.

Looks for near-Earth asteroids

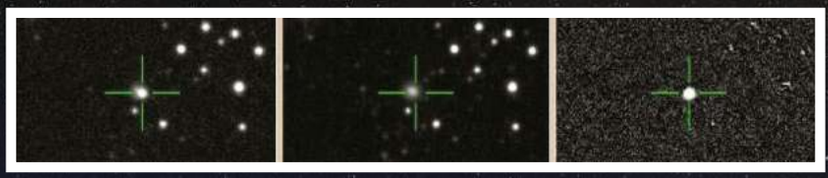
To date, ATLAS has found 160 near-Earth asteroids and 19 potentially hazardous asteroids as part of its main role of providing an early warning system. These observations are submitted to the Minor Planet Center for astronomers to monitor. They can then seek to calculate how much of a danger the objects pose.

Picks up on comets and supernovae

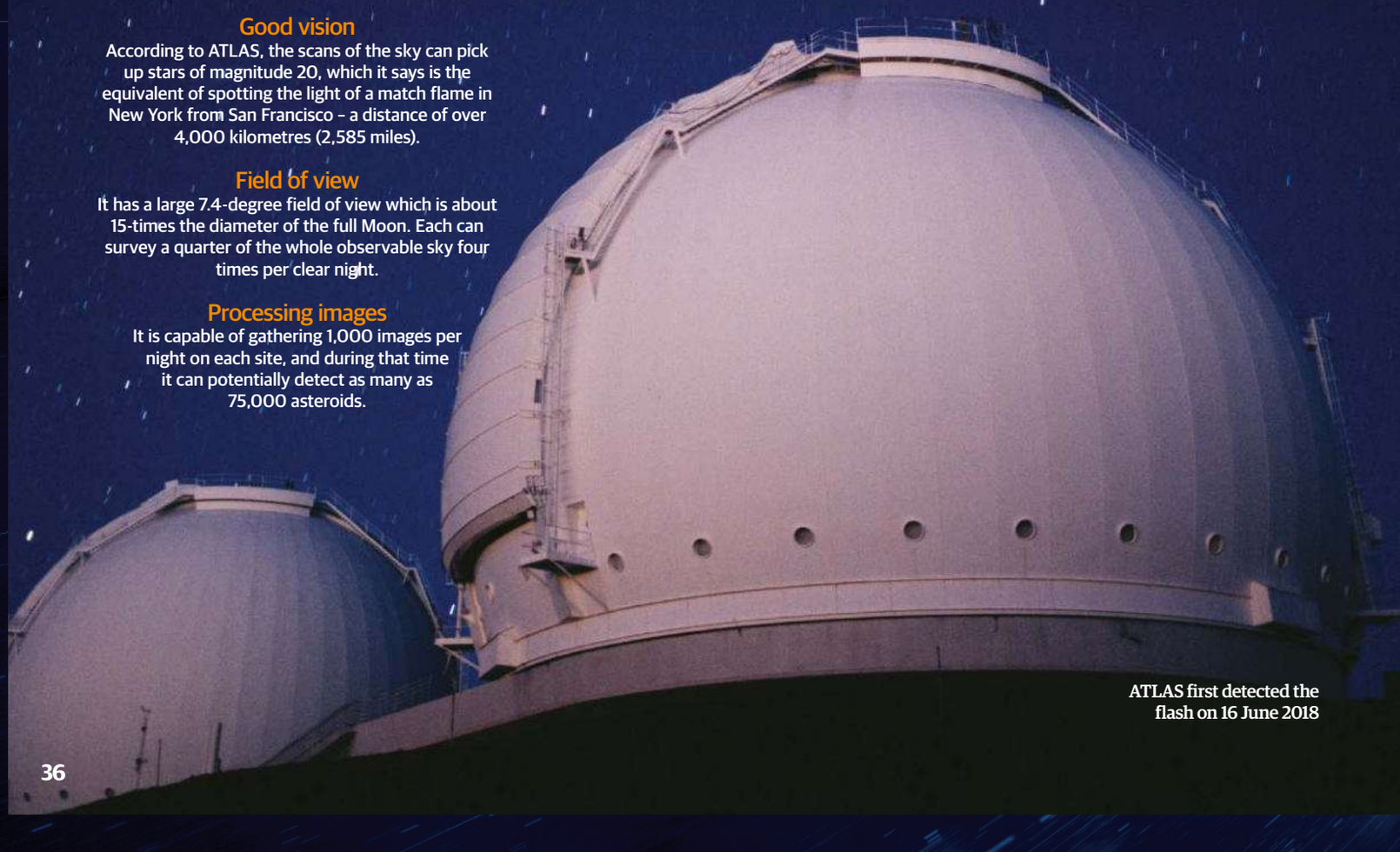
ATLAS can be used to spot transients including supernovae, cataclysmic variables, fast transients such as gamma-ray burst afterglows and stellar outbursts. So far it has reported 1,868 supernovae to the IAU Transient Name Server. The programme for identifying the various objects is run by Queen's University Belfast.

Searches for electromagnetic counterparts

Having struck an agreement with the Laser Interferometer Gravitational-Wave Observatory, which runs a large-scale physics experiment to detect cosmic gravitational waves, ATLAS is used to search for electromagnetic counterparts to any wave sources.



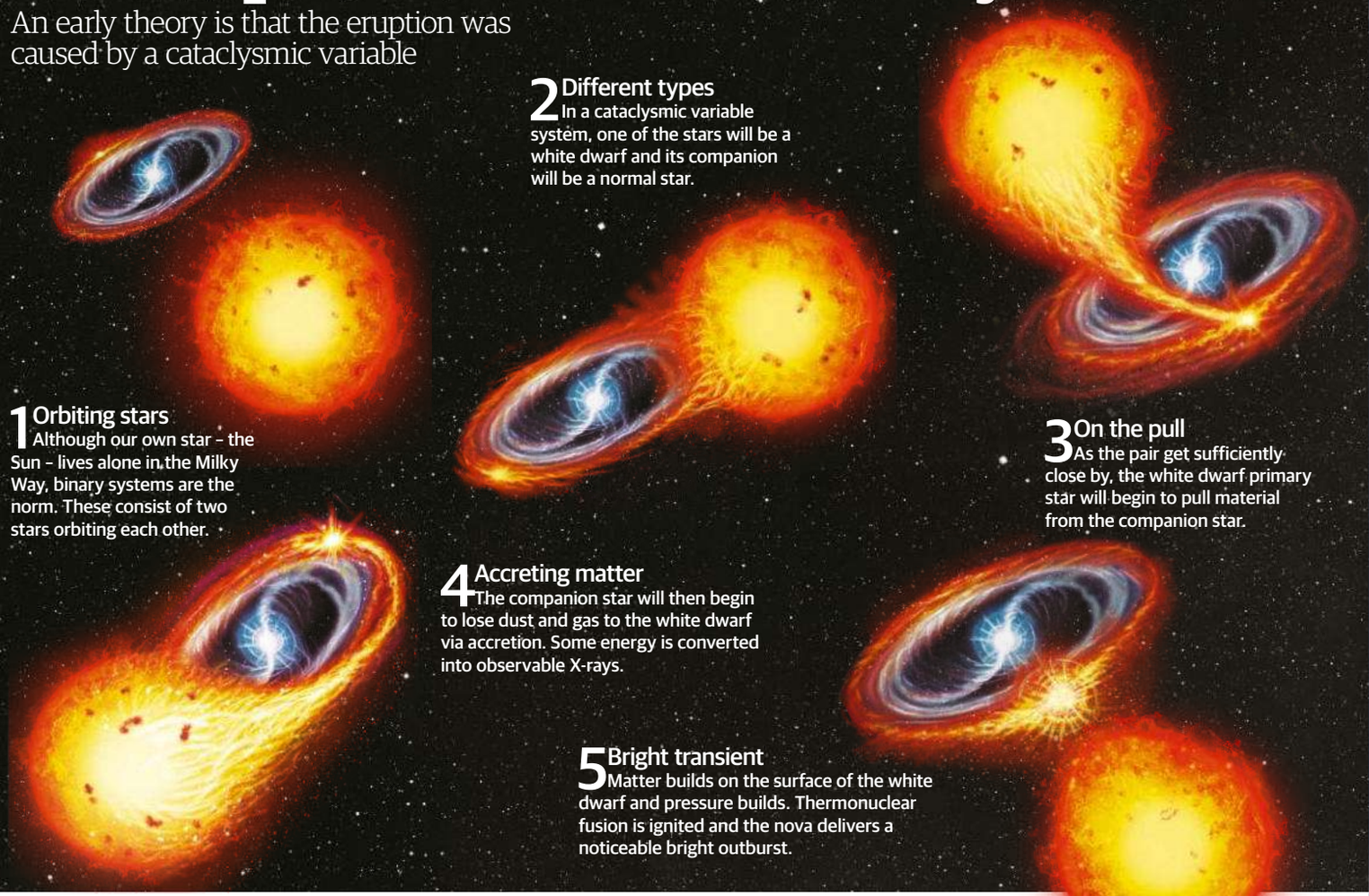
This series of images was captured by the ATLAS telescopes showing the aftermath of the explosion, the blast in progress and the difference between the two



ATLAS first detected the flash on 16 June 2018

The explosion: what it's likely to be

An early theory is that the eruption was caused by a cataclysmic variable



1 Orbiting stars
Although our own star – the Sun – lives alone in the Milky Way, binary systems are the norm. These consist of two stars orbiting each other.

2 Different types
In a cataclysmic variable system, one of the stars will be a white dwarf and its companion will be a normal star.

3 On the pull
As the pair get sufficiently close by, the white dwarf primary star will begin to pull material from the companion star.

4 Accreting matter
The companion star will then begin to lose dust and gas to the white dwarf via accretion. Some energy is converted into observable X-rays.

5 Bright transient
Matter builds on the surface of the white dwarf and pressure builds. Thermonuclear fusion is ignited and the nova delivers a noticeable bright outburst.

This was a crucial observation. "It rose about five magnitudes in the space of three days, and that is very unusual for an object," Maguire explains. "Typically such objects take 18 days to peak so what we observed was a really fast transient. The combination of a very fast rise and it being very bright is why there is so much interest."

But just how close is the object, and is it really part of our own galaxy? To answer that, Chinese astronomers rapidly began spectroscopic observations, separating the object's light into its component wavelengths. This proved to be a breakthrough because it demonstrated that the explosion and the huge flash that resulted was not from our galaxy, but one called CGCG 137-068. This is some 200 million light years away in the constellation Hercules.

"We realised pretty soon after getting the first spectrum data that the object was associated with something extragalactic," says Maguire. "If it had been a variable star in our own galaxy then we would have expected it to look very different. We then saw the absorption and emission lines and that confirmed the host galaxy."

The object proved to be bright across all parts of the electromagnetic spectrum, with strong X-ray and radio signals giving bright readings. It was also discovered that the explosion was unusually fast. High-energy particles fired outwards at 20,000 kilometres (12,427 miles) per second and the surface temperature registered as high as 9,000 degrees Celsius (16,232 degrees Fahrenheit).

"Normally you see a rapid change and you see these absorption features and the velocities go down very quickly, but we're not seeing that in this object so that's very unusual," says Maguire. "We need a new theory to try and predict and understand that." Such theories are being studiously worked on across the globe as astronomers try to get to grips with the object and make more sense of it. Some 24 telescopes are being used on four continents and in space for this very purpose, each one keenly scanning the sky and studying the occurrence, allowing astronomers to eliminate more possibilities. The hope is that they will eventually strike gold, or at the very least come up with a viable explanation for what has caused the intense blast.

The Crab Nebula (Messier 1) is a supernova remnant in Taurus

"It rose about five magnitudes in the space of three days, and that is very unusual for an object" **Dr Kate Maguire**

In fact, the only thing that we can be truly certain of with this remarkable flash is the name that has been given to the object: AT2018cow or, as astronomers have nicknamed it, 'The Cow'. This has simply been a quirk of *The Astronomer's Telegram*'s letter naming system. Everything else from that point on is up for debate.

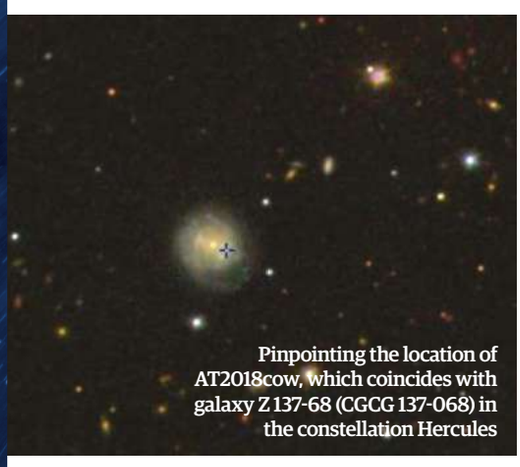
"We have had more notices for 'The Cow' than for any individual object in such a short space of time," says Rutledge of the growing body of work. None of them, however, have successfully been able to match the features of this object with that of those normally seen in supernovae.

Some astronomers have mused that the object could be a Type Ic supernova caused by a collapsing nucleus in a massive star that had already lost its outer veil of helium and hydrogen (it was tentatively given the designation Supernova 2018cow and the classification SN Ic-BL). Others have considered the possibility that it was a gamma-ray burst or a gravitational wave. "I also thought it could be a neutron star-neutron star binary inspiral and so could be a gravitational-wave source," says Rutledge.

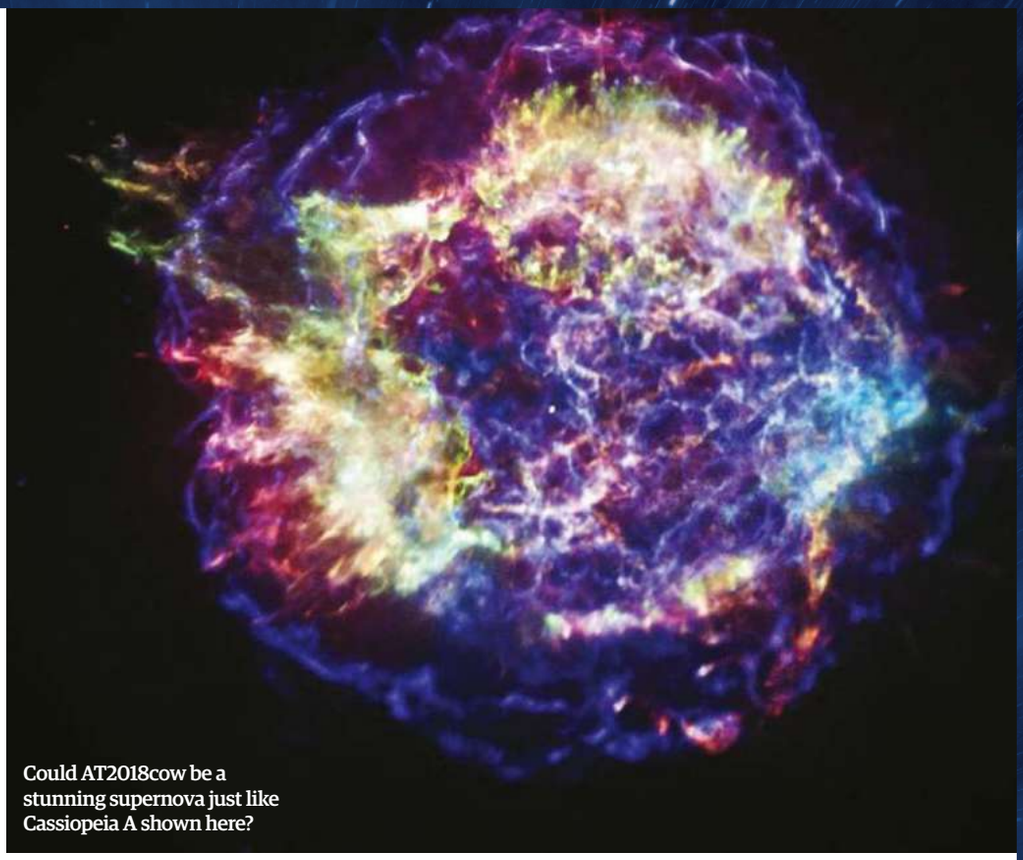
If so that would indeed prove exciting, given the first such NS-NS merger was discovered on 17 August 2017 through the detection of gravitational waves. Yet, in the ensuing scrabble to discover more and more about the object, doubt has been cast on all of the theories. It's going to be a long while before this is pinned down, it seems.

Indeed, Shubham Srivastav, a post-doctoral fellow at the Indian Institute of Technology (IIT) Bombay emailed *The Hindu* news outlet to discuss the possibility of it being a broad-line supernova of Type Ic. "Its detection in X-rays and radio waves does link to one of these broad-line Type Ic supernovae where you have some kind of very energetic central object," says Maguire. But Srivastav said its nature remains a puzzle. "Even if it is a Type Ic supernova, it will not be a conventional one," added Varun Bhalerao, also from IIT.

As for its potential to be a NS-NS inspiral and therefore a gravitational-wave source, Rutledge says: "I care a lot about the new discoveries of neutron star-neutron star binary inspiral sources because they might teach us something about how the Strong Force, which holds nuclei together, works." He also points to subsequent studies which have found evidence of iron. This, he points out, is "a marker for a type of supernova which is not a NS-NS inspiral".



Pinpointing the location of AT2018cow, which coincides with galaxy Z 137-68 (CGCG 137-068) in the constellation Hercules



Could AT2018cow be a stunning supernova just like Cassiopeia A shown here?

"I also thought it could be a neutron star-neutron star binary inspiral and so could be a gravitational-wave source" **Robert Rutledge**

"I think it would have been very exciting if we were able to test for gravitational waves," adds Maguire. Yet this has not been possible. The issue here is a frustratingly practical one; the twin detectors of the Laser Interferometry Gravitational-Wave Observatory (LIGO) are currently receiving underground upgrades which means they cannot be used at the moment.

"They are not operational, and yet I think it would have been very exciting if we were able to see if there were any gravitational waves" says Maguire. "So yes, it would have been great if we were able to get a gravitational-wave detection and then confirm it was some kind of merger of stars, but unfortunately that is not possible."

Instead, other tests have been taking place, including those by Dr Antonio de Ugarte Postigo of The Institute of Astrophysics of Andalusia. "We wanted to look more closely at 'The Cow' because the object is unique," he says. "Since it was as luminous as the most luminous supernovae that we know and because it reached peak emission much earlier than one could expect for a normal supernova, it meant its classification as a supernova explosion was very complicated within our current classification schemes. We had to look for alternative explanations."

Dr de Ugarte Postigo is relishing the chance to come up with some answers. "For a scientist it's always exciting to observe things that you don't fully understand," he says. "After receiving the information about this peculiar new source, our team, HETH [High-Energy Transients and their Hosts] in Granada, Spain, immediately began to discuss what kind of observations we would need to explain this object and got to work."

His team quickly found a non-thermal emission, which has been interpreted as being due to a relativistic outflow. "The detection in millimetre wavelengths showed that there is a strong synchrotron emission contributing to the light that we see from this object," he explains. "This type of radiation is produced by highly accelerated particles and is often observed in stellar explosions, like gamma-ray bursts, when very rapid material ejected from the exploding star collides with the interstellar environment. Seeing this in 'The Cow' implied that the explosion was not just a usual supernova, but probably one with some kind of relativistic outflow."

Yet of the current theories, Rutledge, who also works in the Department of Physics at McGill University in Montreal, Quebec, Canada, favours a massive stellar-collapse supernova. The finding of iron, he says, is a marker of a collapse of a massive star the size of tens of solar masses.

"I think this is the most likely explanation," he tells us. And the massive-stellar-collapse stars are physically interesting for other reasons, for understanding how stellar evolution and the production of different elements in the universe works. It's also important for further study to help figure out markers to differentiate, as early as possible, between this type of supernova and the NS-NS binary inspiral type."

This is far from the definitive answer, and there's no chance of the puzzle being solved any time soon. It's likely to rumble on. "People will put out some of their initial data and we'll continue to have suggestions, but this won't be solved in the next couple of days, that's for sure," concludes Maguire.

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Obliterating space junk with a laser cannon

The Russian space agency has recently announced plans to turn a three-metre optical telescope into a debris destroyer

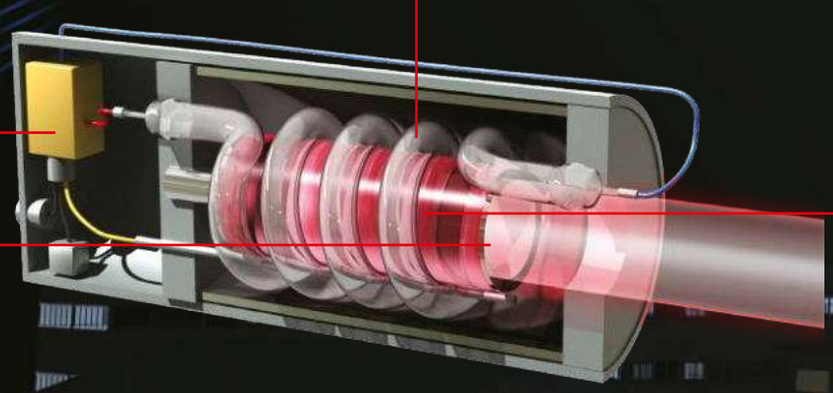
It's not quite the calibre of the Death Star from *Star Wars*, but Russian space agency Roscosmos is planning to build a laser cannon that will clean up low-Earth orbit, one piece of space junk at a time. Scientists at the Research-and-Production Corporation Precision Systems, which is a subdivision of Roscosmos, aim to attach a giant laser cannon on to a three-metre optical telescope. This laser cannon would have a carefully designed mechanism attached to the telescope, which utilises a series of reflective mirrors, a quartz flash tube and a solid-base generator power supply to create a laser beam powerful enough to evaporate pieces of metal floating around in space.

This telescope is already under development, and its main purpose is to monitor satellites and any potentially dangerous pieces of space junk floating between 160 to 2,000 kilometres (100 to 1,242 miles) above the Earth's surface. NASA estimates that there are over 500,000 pieces of space junk that are marble-sized or larger in low-Earth orbit, and they can reach speeds of up to 28,164 kilometres (17,500 miles) per hour. These pieces of junk are left over debris from obsolete satellites, space stations or fragments from space collisions. With the International Space Station (ISS) and even more satellites being put into low-Earth Orbit, these pieces of junk can pose a major threat. They could also potentially break through the atmosphere and find their way to the ground, proving to be a potential hazard to us.

Previous events emphasise the dangers of space debris, including the Kosmos-954 incident in January 1978, when the former Soviet reconnaissance satellite reentered the Earth's atmosphere over Canada; in doing so it broke up into smaller pieces and deposited radioactive material over some 124,000 square kilometres (47,877 square miles) of land. Also, in April 2016, a chip in one of the ISS' glass panels was thought to be caused by the impact of a tiny piece of space debris – possibly a paint flake or a tiny metal fragment. If it wasn't for the quadruple-glazed glass, there could have been a serious problem.

For these reasons, the issue of space junk and its disposal has become more important to organisations such as NASA, ESA and Roscosmos. Previous suggestions to remove space junk have included a massive space-net and solar sails to push the debris out of its current orbit. The idea of a 'giant laser cannon' is an interesting concept, as it would require a solid-base generator attachment among other instrument concepts to bring this science-fiction idea into reality.

The intensified light would bounce off the mirrors of the telescope until a powerful laser beam is created, which can remove space debris through a process called 'laser ablation'. This is commonly used to remove layers of material from metals or industrial compounds. However, in the case of this new technology, this laser beam would be able to heat space debris up to temperatures where it would evaporate and be obliterated.



Power supply
This solid-base generator will excite electrons. This will emit the light waves that constitute laser beams before being concentrated through the mirrors and flash tube.

Quartz flash tube
This can be thought of as an 'optical pump'. Once the power is turned on the current begins to flow through the quartz flash tube, which then begins to glow.

Reflective mirror
Using a series of mirrors with different percentages of reflectivity, the excited photons of light are thrown back into the quartz flash tube, amplifying the light into a laser beam.

"The intensified light would bounce off the mirrors of the telescope until a powerful laser beam is created"

Laser beam
The resulting laser beam will have to be powerful enough to heat up objects in low-Earth orbit at least 160 kilometres (100 miles) away.

Aluminium cylinder
This cylinder is highly polished, like a curved mirror, and is the protective container for all these delicate materials.

Ruby crystal
Light from the quartz flash tube will strike the ruby crystal and power up its internal atoms to a higher energy level.

Planet Profile

Uranus

The ice giant that is shrouded in mystery has fascinated explorers for decades

The seventh planet from the Sun, Uranus became the first planet to be found with the aid of a telescope on 13 March 1781 by British astronomer William Herschel. On that fateful night, he described observing a "nebulous star or perhaps a comet". Little did he know that he had just discovered Uranus – named after the the Greek god of the sky – a name proposed by Johann Elert Bode in 1783.

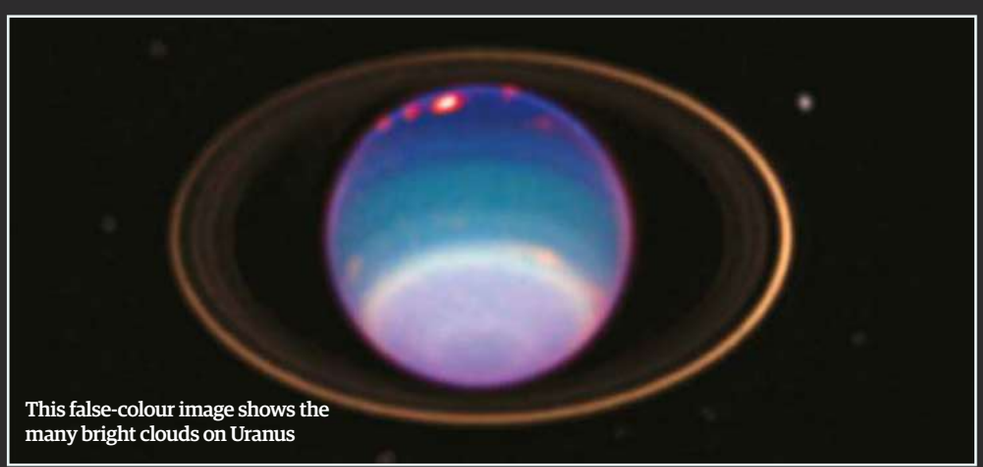
Over 230 years later, Uranus still remains to be a puzzle. What is known is that Uranus is located about 2.9 billion kilometres (1.8 billion miles) from the Sun, about 19-times the distance from Earth to the Sun, meaning that one orbit of the Sun takes 84 Earth years. The planet is enormous, with a diameter of 50,724 kilometres (31,518 miles) – four-times wider than the Earth.

Uranus has a compositional mass that is 80 per cent a fluid mixture of water, ammonia (NH_3) and methane (CH_4) ices. It is the methane in the outer atmosphere that gives it its blue-green colour, but the thick cloud coverage does not allow our instruments to peer down any further, and is one reason why Uranus remains an enigma.

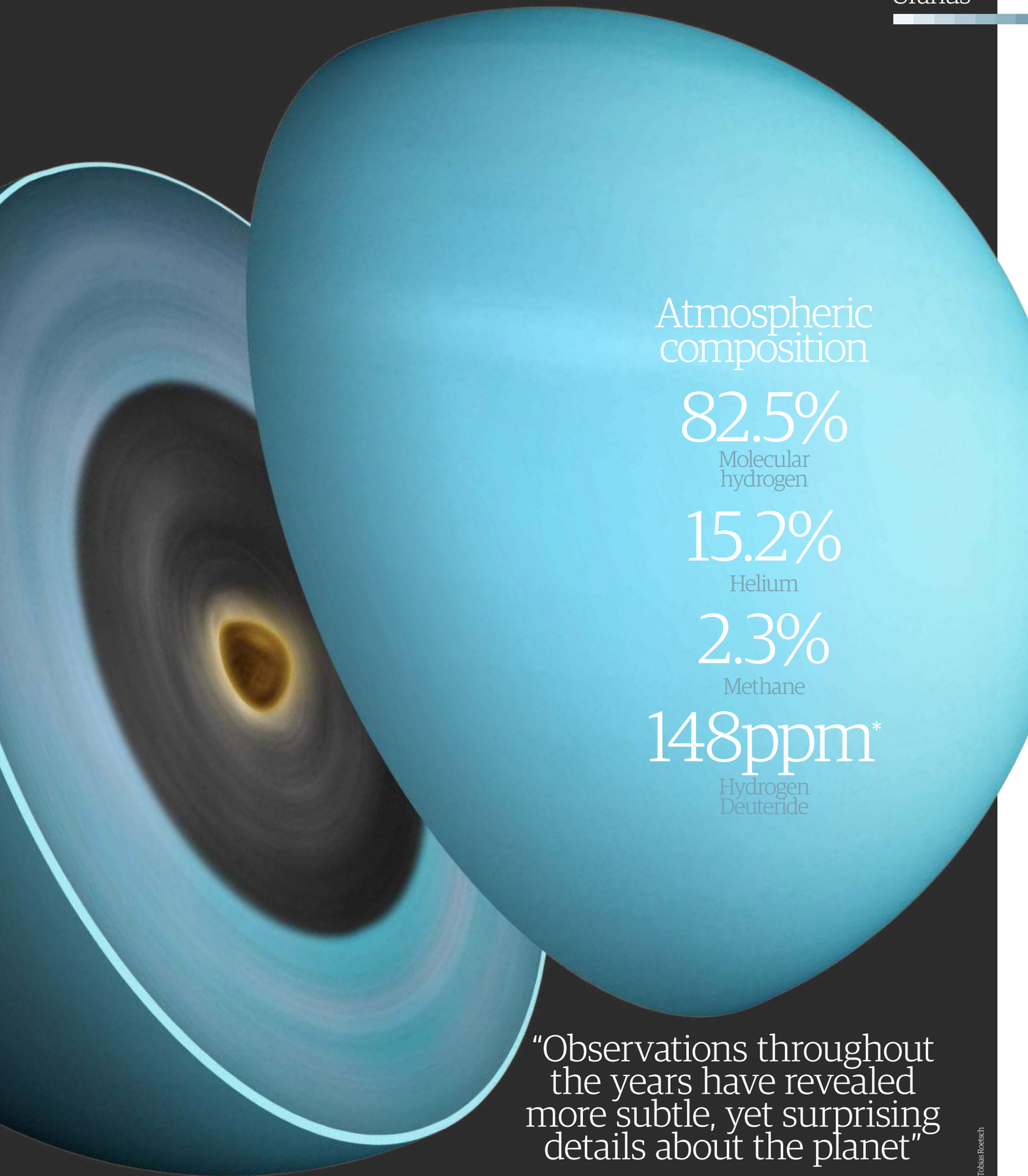
What astronomers strongly suggest is that below the planet's cloud tops is a main atmosphere which contains mostly hydrogen and helium by composition and has traces of methane and other volatiles. Below that is the fluid icy mantle, which makes up most of its composition by mass, but it is also theorised that the pressure and temperatures are enough to make it 'rain diamonds' at that depth. Finally at the centre is the silicate iron-nickel core, thought to be between half to just over three-times the mass of the Earth.

Although there has only been one mission to visit the ice giant close up – Voyager 2 in 1986 – the planet has long been studied by ground- and space-based telescopes such as Hubble and the Keck Observatory in Hawaii, United States. Observations throughout the years have revealed more subtle, yet surprising details about the planet. These include the planet's thin rings, which confirmed that Saturn is not an outlier and rings can form around any planet. Astronomers have also been able to deduce that Uranus' planetary rotational tilt is off by a notable 97.77 degrees, which implies there was a collision in its early age that knocked it over.

Similar to the larger gas giants, Jupiter and Saturn, storms have been observed brewing in the cloud tops of Uranus. In November 2014 the planet was extremely active; storms raged on Uranus that were even observed by amateur astronomers. These observations caused another dilemma in regards to Uranus. As there seems to be no internal heat source and it's a huge distance from the Sun's heat, astronomers question what's going on inside Uranus to make such storms arise. "The colours and morphology of this cloud complex suggest that the storm may be tied to a vortex in the deeper atmosphere similar to two large cloud complexes seen during the equinox," said Larry Sromovsky, a planetary scientist at the University of Wisconsin, Madison, United States at the time of its discovery.



This false-colour image shows the many bright clouds on Uranus



Atmospheric composition

82.5%
Molecular hydrogen

15.2%
Helium

2.3%
Methane

148ppm*
Hydrogen Deuteride

"Observations throughout the years have revealed more subtle, yet surprising details about the planet"

*parts per million

Uranus in the news

Knocking Uranus about

Uranus is shrouded in subtle mysteries, including its near 90-degree axial tilt and its substantially cold observed temperatures. Astronomers at Durham University, United Kingdom, have recently completed multiple computer simulations focused on collisions with Uranus and state that these certain characteristics can be explained by an ancient, calamitous collision that took place roughly 4 billion years ago with an object twice the size of Earth.

"We ran more than 50 different impact scenarios using a high-powered super computer to see if we could recreate the conditions that shaped the planet's evolution," says Jacob Kegerreis, a PhD researcher at Durham University's Institute for Computational Cosmology. "Our findings confirm that the most likely outcome was that the young Uranus was involved in a cataclysmic collision with an object twice the mass of Earth, if not larger, knocking it on to its side and setting in process the events that helped create the planet we see today."

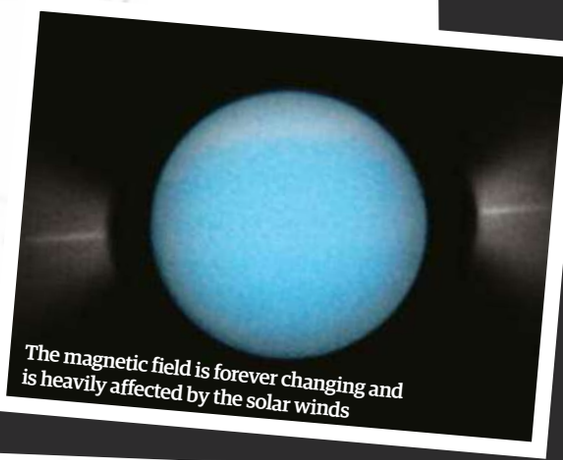
Not only did this collision from the young protoplanet knock Uranus on its side, but the mystery impactor left a layer of insulating debris that keeps in the internal heat of Uranus. By insulating the ice giant, it would explain why we observe freezing temperatures of -216 degrees Celsius (-357 degrees Fahrenheit) on the planet's outer atmosphere.

Uranus' unsettled magnetopshere

It's been over 30 years since Voyager 2's flyby of Uranus, but its data is still fuelling more discoveries about the planet. Recently researchers from the Georgia Institute of Technology, United States, have used Voyager 2 data to reveal that Uranus' magnetosphere, the region encompassing the planet powered by its magnetic field, turns on and off like a light switch every day as it rotates around the planet. When the magnetosphere is 'open' solar winds are allowed to flow into it; if the magnetosphere is 'closed' it is essentially a shield that guards against the solar wind and deflects it away.

"Uranus is a geometric nightmare," says Carol Paty, a Georgia Tech associate professor. "The magnetic field tumbles very fast, like a child cartwheeling down a hill head over heels. When the magnetised solar wind meets this tumbling field in the right way it can reconnect, and Uranus' magnetosphere goes from open to closed to open on a daily basis."

The fact that Uranus rotates on its side and its magnetic field is off-centre and tilted by 60 degrees from its axis causes the magnetic field to fall asymmetrically relative to the solar wind direction.



The magnetic field is forever changing and is heavily affected by the solar winds

Uranus smells like rotten eggs

Recent observations from the Gemini North telescope, located on Hawaii's Mauna Kea summit, revealed that hydrogen sulphide resides on the clouds of Uranus. This gas is what gives rotten eggs their distinctive smell, and it has been found to be one of the key ingredients that make up the clouds. This result came from dissecting the infrared light by Gemini's Near-Infrared Integral Field Spectrometer (NIFS) to reveal the spectral signature of different molecules.

"This work is a strikingly innovative use of an instrument originally designed to study the explosive environments around huge black holes at the centres of distant galaxies," says Chris Davis of the United States' National Science Foundation, a leading funder of the Gemini telescope. "To use NIFS to solve a longstanding mystery in our own Solar System is a powerful extension of its use."

It has also been stated that by confirming the presence of this gas it confirms that there are distinct differences between the ice giants, Uranus and Neptune, and the other two gas giants, Jupiter and Saturn.

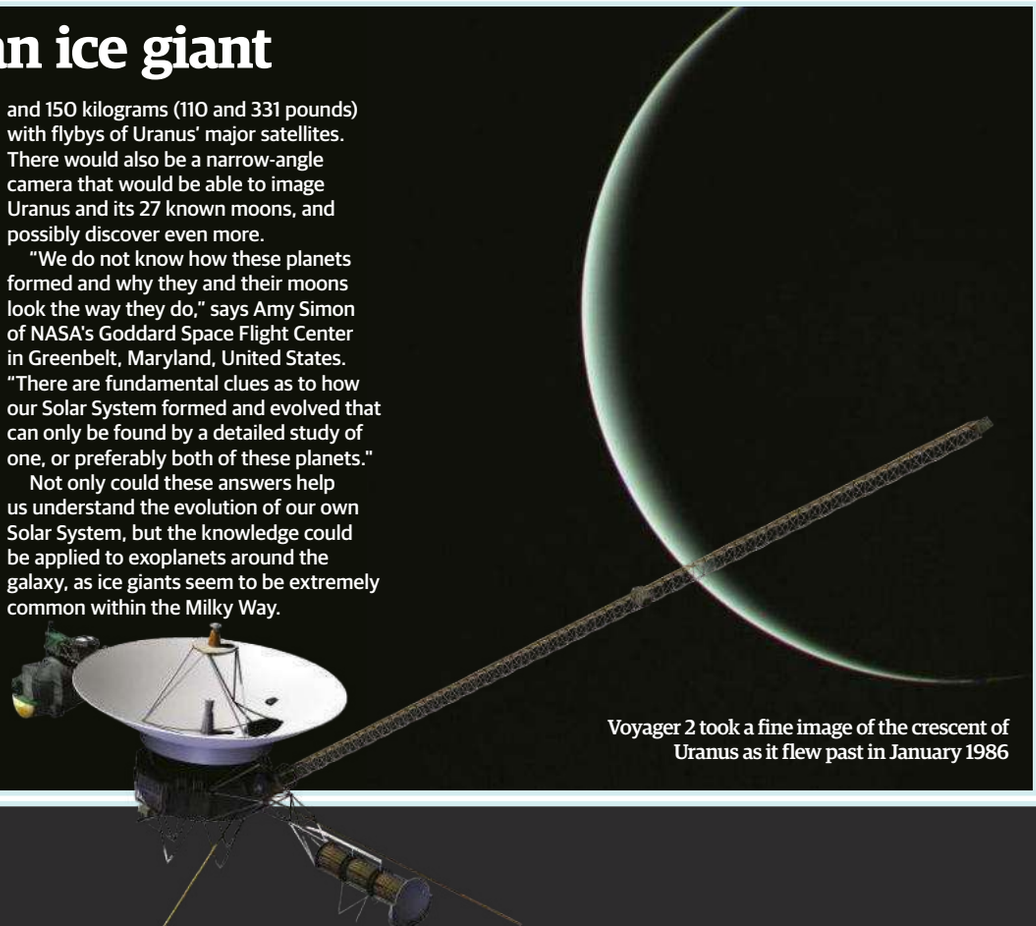
Exploration of an ice giant

Uranus is a relatively secluded planet, with a grand total of one spacecraft having visited it in the past. This lone ranger, NASA's Voyager 2 interplanetary probe, flew past the distant ice giant Uranus in 1986 while on its way out of the Solar System. Voyager 2 was able to get within 81,500 kilometres (50,642 miles) of the cloud tops, and its suite of instruments got to work. This flyby provided valuable data of the planet's atmosphere, rings, moons and magnetic field. This included the discovery of 11 new moons, two new rings and revealed that the planet's rotation rate is 17 hours and 14 minutes per rotation.

Although no spacecraft is currently exploring Uranus up close, there are preliminary plans in place to head to both Uranus and Neptune. NASA's Pre-Decadal Survey Mission Study outlines why Uranus and Neptune should be two of the next targets of exploration and contains a variety of potential orbiters with a probe that could dive into Uranus' atmosphere. There could also be an orbiter carrying a payload between 50 and 150 kilograms (110 and 331 pounds) with flybys of Uranus' major satellites. There would also be a narrow-angle camera that would be able to image Uranus and its 27 known moons, and possibly discover even more.

"We do not know how these planets formed and why they and their moons look the way they do," says Amy Simon of NASA's Goddard Space Flight Center in Greenbelt, Maryland, United States. "There are fundamental clues as to how our Solar System formed and evolved that can only be found by a detailed study of one, or preferably both of these planets."

Not only could these answers help us understand the evolution of our own Solar System, but the knowledge could be applied to exoplanets around the galaxy, as ice giants seem to be extremely common within the Milky Way.



Voyager 2 took a fine image of the crescent of Uranus as it flew past in January 1986

Uranus Facts

-218

Uranus is the coldest planet in the Solar System, with a lowest recorded temperature of -218 degrees Celsius (-370 degrees Fahrenheit).

Along with Neptune, Uranus is more commonly referred to as an 'ice giant', as opposed to a 'gas giant', due to its icy mantle.

27

Uranus has 27 known moons, all of which are named after characters from the works of William Shakespeare and Alexander Pope.

In Uranus' mantle, the pressure and temperatures are ideal for creating nanosize diamonds, making it theoretically possible to 'rain diamonds'.

10-15x

The winds at Uranus can reach supersonic speeds and can create jet streams which are 10 to 15 times more powerful than anything seen on Earth.

90

Uranus rotates at a nearly 90-degree angle, thought to have been caused by a massive object roughly twice the size of Earth striking it.

17

A day on Uranus is only approximately 17 hours long and rotates backwards compared to the Earth.

13

Uranus has 13 known rings around it. The inner rings are narrow and dark while the outer rings are brightly coloured.

DRONES FLOATING ON THE CLOUDS OF VENUS

With renewed interest in 'Earth's evil twin' once again, companies are uniting to create a craft that can examine the planet up-close

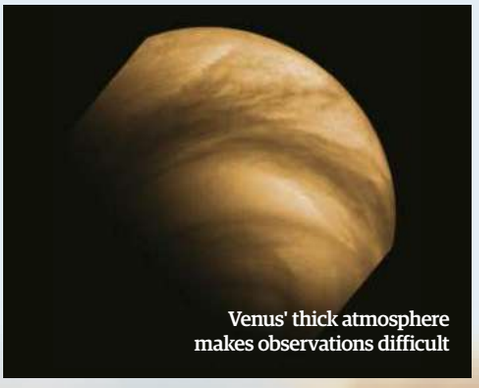
Plans are slowly falling into place to explore Venus in a new and innovative way using a hard-shelled drone to swoop over the thick cloud tops, with the aim to learn about the planet's past and present. Although Venus has always been regarded as an inhospitable environment, given that it is the hottest world in the Solar System with surface temperatures of 465 degrees Celsius (869 degrees Fahrenheit), recent research has turned a lot of scientists' attention back in the direction of our planet's 'evil twin'.

Although the surface temperature of the planet is hot enough to melt lead, recent findings have revealed some interesting theories about its past. It is thought that once upon a time, Venus had a liquid ocean that covered 60 per cent of the planet and was present for approximately two billion years. Looking into the clouds, life as we know it could be more favourable because of its ideal pressures and temperatures, and that's where NASA and its new partner company Black Swift Technologies are planning to venture.

Black Swift Technologies is an engineering firm based in Boulder, Colorado, United States, which specialises in small, unmanned aircraft systems. It has been dealt the difficult task of constructing a drone capable of surviving the dangers of Venus' upper atmosphere. If in six months' time its design is up to scratch, NASA will award it with a lucrative contract that will allow it to bring the drone to life. NASA has already awarded the company an initial six-month contract just for the design, which includes a £94,750 ($125,000) grant by the federal government's Small Business Innovation Research program.

The prefatory plans seem extremely promising; the company has already outlined that it wishes to take its knowledge and experience of making unmanned aircraft that can survive in storms on Earth and apply that to the Venus drone. It has also outlined its ambition to harness the power of Venus' upper atmosphere, which contains clouds of sulphuric acid and could also support the presence of microorganisms in the form of extremophiles – microorganisms that thrive in extreme environments. Although this is a long shot there is little evidence to confirm or disapprove this idea, giving more incentive to send a drone to find out more.

The potential of this mission is revolutionary in terms of studying our neighbouring planet, which is roughly the same size as Earth but incredibly heated up due to its atmospheric build-up of greenhouse gases. The drone could peer through the clouds and reveal the surface that is littered with volcanoes to help us understand its true evolution and current state.



Venus' thick atmosphere makes observations difficult

Venus has an atmosphere consisting mostly of carbon dioxide, with clouds of sulphuric acid

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A Model Aircraft
THE RAF RED ARROWS HAWK

The British Aerospace Hawk is one of the most important British jets. Having first flown as the Hawker Siddeley Hawk in Surrey in 1974 the Hawk is still in production in the UK today and is sold to many different countries all over the world. The Hawk is considered a "low-cost" combat aircraft, in 2003 one would've reportedly cost you approximately £18 million!

Without doubt, the most famous of the 1000+ BAe Hawks produced are the aircraft which wear the distinctive colours of the Royal Air Force Aerobatic Team 'The Red Arrows', arguably the world's best and certainly the most famous aerobatic display team.

The Red Arrows have been performing their thrilling displays to audiences all over the world since 1965, fulfilling the role of Britain's most effective flying ambassadors wherever they appear. To join the Red Arrows display team candidates have to have completed a front line tour as a Royal Air Force pilot, have a minimum of 1500 flying hours and be assessed as "above average" in their current RAF flying role. A maximum of three new pilots are chosen each year so the pilots of the Red Arrows really are the best of the best!

The Red Arrows have appeared in almost 5,000 displays in over 50 countries. A global television audience of over one billion people watched the flypast they performed at the London 2012 Olympic Games Opening Ceremony. The Hawks of the Red Arrows really are amongst the most famous aeroplanes in the history of aviation.

The Red Arrows Hawk is a British icon and you can recreate your own at home with an Airfix QuickBuild kit. QuickBuild kits give you the ability to recreate a wide variety of iconic aircraft, tanks and cars into brilliant scale models. No paint or glue is required, the push together brick system results in a realistic, scale model that is compatible with other plastic brick brands.

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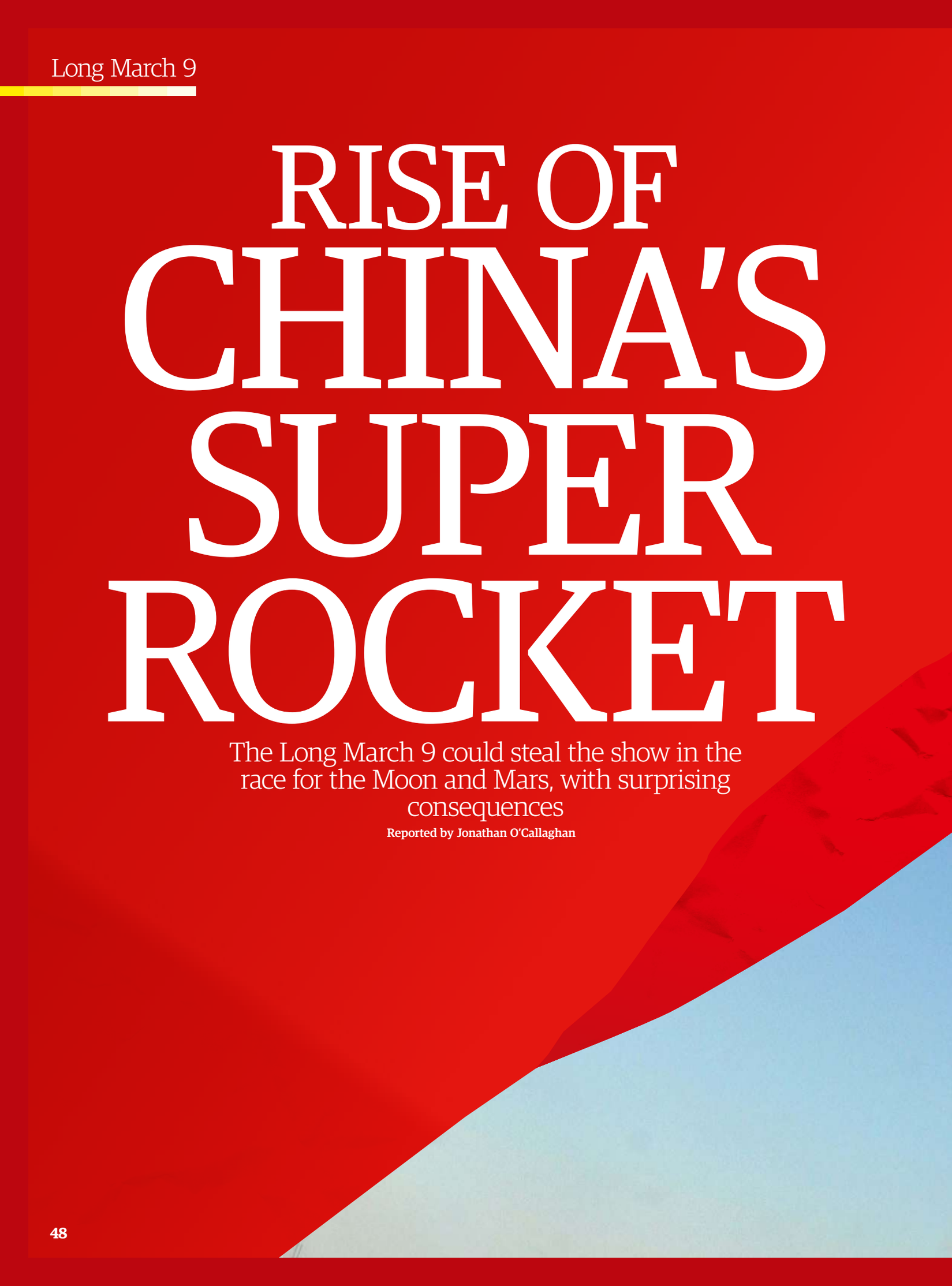
RISE OF CHINA'S SUPER ROCKET

The Long March 9 could steal the show in the race for the Moon and Mars, with surprising consequences

Reported by Jonathan O'Callaghan



© VCG/ Getty

At the turn of the century China had yet to send a human to space. But the 2003 launch of Yang Liwei on the Shenzhou 5 spacecraft propelled the country's space programme into the limelight. Now, more than a decade on, their space exploits have advanced at a pace few thought possible. They have launched humans to an experimental space station, landed a rover on the Moon and are planning a mission to the far side of the Moon in late-2018. They have made no secret that their ultimate goal is to send humans to the Moon, or even Mars. And to do so, they're going to need a massive rocket.

Step forward the Long March 9, China's answer to NASA's Saturn V rocket. Revealed in detail in July 2018, this super-heavy-lift rocket would tower 93 metres (305 feet) high, and would have enough lifting capacity to make exciting exploration missions possible. And while its inaugural launch date of 2030 seems quite far off, China has been pretty successful in sticking to its plans so far.

"The project indicates that China is set on becoming a major space power, capable of matching and perhaps even surpassing in some ways the exploits of the US and Soviet Union or Russia," Andrew Jones, a journalist who reports on China's

space programme, tells **All About Space**. "The aim will also be to boost China's level of high-end science and technology, bringing benefits to the economy as well as inspiring younger generations and displaying to the public what China can achieve under the leadership of the Communist Party."

As its name implies, the Long March 9 is the latest in the Long March series of rockets. Named for a famous military retreat by the Red Army from 1934, this family of rockets has completed nearly 300 launches since 1970, with numbers considerably ramping up in the past ten years. Although there have been some notable failures, China has made huge strides with its rockets, launching its biggest version so far – the Long March 5 – back in November 2016. But the country has large ambitions, larger than can be fulfilled by its existing fleet of rockets.

Its purported missions are impressive. China has suggested it may look to build a base on the Moon or even send humans to Mars, both of which would require a large rocket like this. The inaugural flight of the Long March 9 in 2030, meanwhile, would be a Mars sample return mission, landing an uncrewed lander on the Red Planet and bringing material back to Earth. NASA too is hoping to attempt such a mission in the 2020s, but any delays and they may find themselves in a race with the Chinese. "China could end up edging the United States in pulling off such a mission, which could potentially bring evidence of past or extant extraterrestrial life. Such a discovery would have a profound influence on human history, no matter who makes it," says Jones.

Essentially, the bigger and more powerful your rocket, the more stuff you can take to space and the further you can go. This is why rockets come in all sizes, with the smallest – known as sounding rockets – just making a short hop into space. The biggest, the heavy-lift rockets, are capable of taking large satellites into geostationary orbit, or even sending probes into the distant Solar System. However, if you want to start sending people far away, have your eye on building a space station or want to bring material back from Mars, you need a super-heavy-lift rocket.

Only the Saturn V arguably falls in this class, with the Soviet Union trying – and failing on multiple occasions – to emulate its success with their N1 rocket in the 1960s and 70s. SpaceX recently launched the Falcon Heavy, the most powerful rocket in operation today, but it doesn't quite hold a candle to the Saturn V. There are new giant launch vehicles in development in the US though, notably NASA's Space Launch System (SLS) and SpaceX's Big Falcon Rocket (BFR). Both have inaugural launch dates planned in the early 2020s, meaning that China might be a little late to the party, but its designs are no less ambitious.

According to the China Academy of Launch Vehicle Technology (CALT), there is a plan in the works to use the Long March 9 as part of a future crewed lunar mission. The rocket would be used to launch the lander and equipment necessary for the lunar excursion, while the crew would launch separately in a next-generation spacecraft being developed on the smaller Long March 5B. The two would rendezvous in Earth orbit, from which the astronauts – known as taikonauts in China – would make their way to the lunar surface.

China is still in the very early stages of developing this rocket, which has not yet been given official approval from the government. They have recently tested out a large-thrust solid rocket motor, but the eventual engines for this rocket – billed as having 500-metric-ton-thrust of kerosene-liquid-oxygen and 220-metric-ton-thrust of liquid-hydrogen engines – are still being ironed out. Later this year they may test a prototype of the large engine, fuelled by kerosene, built by the country's Academy of Aerospace Propulsion Technology

Can China succeed in sending humans back to the Moon, or even Mars?

"The project indicates that China is set on becoming a major space power, capable of matching the US or Russia" **Andrew Jones**

Scientists monitor the docking of Tiangong-1 and Shenzhou 8 spacecraft in 2011

Long March 9 vs BFR, Falcon Heavy, Saturn V and SLS

How China's biggest rocket stacks up to its past, present and future competitors

Big Falcon Rocket

If it's completed, SpaceX's BFR will be the most powerful rocket of them all. The idea is to fly a large booster on top of a single core, with a total height of 106 metres (348 feet). The entire rocket is reusable, with the booster and spaceship able to land on the ground. As there are no expendable stages, it could theoretically take 150,000 kilograms (330,693 pounds) to orbit, the Moon or Mars – including up to 100 people – enough for Elon Musk to realise his dream of colonising the Red Planet. The first uncrewed flight to Mars could be as soon as 2022.

★★★

Falcon Heavy

On 6 February 2018, SpaceX's Falcon Heavy rocket lifted off for the first time, with a dummy payload of Elon Musk's own Tesla Roadster car. Capable of taking 63,800 kilograms (140,655 pounds) to orbit, the Falcon Heavy is the largest rocket in operation today, able to take more cargo to orbit than any rocket since the Saturn V's final flight in 1973. However, the rocket faces an uncertain future, as the market for it is small. Elon Musk has already started to shift focus to its successor, the BFR, noting that he's not sure how often the Falcon Heavy will fly.

★★★

Saturn V

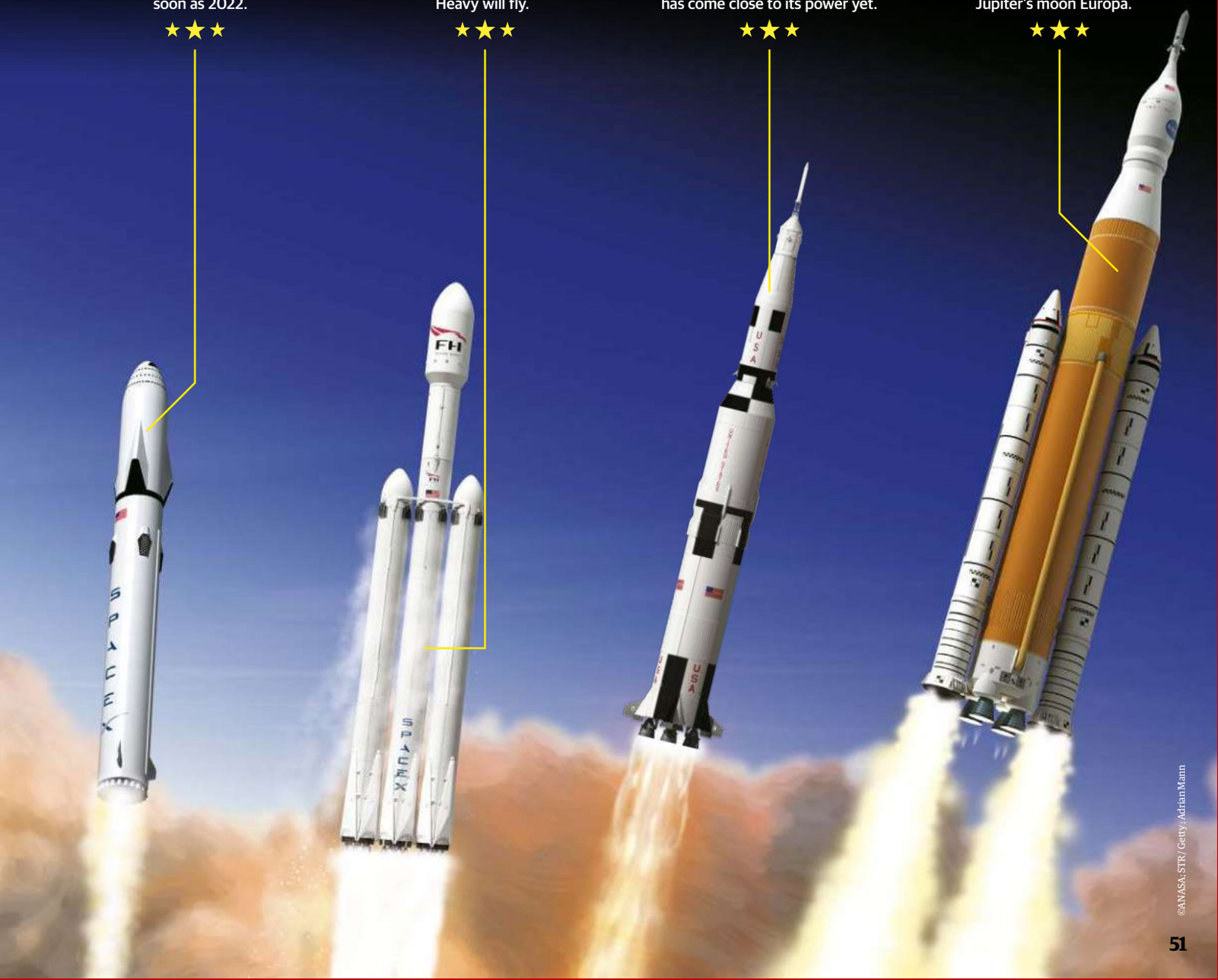
NASA's Saturn V rocket remains the biggest rocket ever built. In total it launched 13 times, and sent six successful Apollo missions to the Moon. Apollo 13 should have been the third Moon mission but due to an explosion on the spacecraft it was forced to abandon the mission. Each launch carried three people, with the rocket capable of taking about 43,500 kilograms (95,900 pounds) to the Moon. This included the lunar lander and the command module, and on later Apollo missions lunar rovers that were driven on the surface. No rocket has come close to its power yet.

★★★

Space Launch System

The Space Launch System (SLS) is NASA's answer to an ever-present desire to explore the Solar System. While some have bemoaned its cost and time taken to build, NASA is pushing ahead with a planned first launch (uncrewed) in 2020. Different variants are being designed, with a payload capacity of between 70,000 and 130,000 kilograms (154,324 and 286,601 pounds). The rocket will be used to launch NASA's crewed Orion spacecraft, capable of taking up to six astronauts to orbit, and it may also launch an uncrewed mission to Jupiter's moon Europa.

★★★



Chinese Space Programme

How the nation has progressed so far in its cosmic ambitions

The first Chinese satellite, Dong Fang Hong 1

1970
First satellite to orbit, the Dong Fang Hong I

1999
Uncrewed first launch of the Shenzhou spacecraft

2003
First human in space, Yang Liwei, on Shenzhou 5

2005
Two astronauts orbit Earth for five days on Shenzhou 6

2007
First lunar probe, Chang'e 1, sent to the Moon

2008
First-ever Chinese spacewalk on the Shenzhou 7 mission

2010
Second lunar probe, Chang'e 2, launches

2011
First experimental space station, Tiangong-1, launches

2012
First woman in space, Liu Yang, aboard Shenzhou 9

2013
Lands first rover, 'Yutu', on the Moon

2016
Second experimental space station, Tiangong-2, launches

2018
Lunar relay satellite launches for upcoming far side landing

Feitian spacesuit
Zhai Zhigang wore this Orlan-M-modelled spacesuit during China's first-ever EVA in 2008

Yang Liwei
He was selected for astronaut training in 1998, becoming the first Chinese taikonaut in 2003

Tiangong-1
Recently made headlines as it crashed back to Earth on 2 April 2018 after over six years in space

Moon rover
The first mission to the Moon since 1972

Liu Yang
China's first female astronaut went to space in 2012

(AAPT). That would be a big step forward in proving they are serious about this rocket.

The China Aerospace Science and Technology Corporation (CASC), the main contractor for the Chinese space programme, has also said it is looking into making the rocket reusable, putting it on a par with the more advanced offerings from SpaceX and Blue Origin. While the details still aren't clear, it appears it's looking into the possibility of the boosters on the Long March 9 being reusable to keep launch costs down. It is planning to test a reusable first stage of a rocket, called the Long March 8, which could launch as early as 2021.

Some argue, though, that such a rocket is unnecessary. China has yet to detail how it would plan to take astronauts to the Moon or Mars, and one could question how much desire there really is to go to these destinations. As NASA found with its Saturn V rocket, and more recently the SLS, big rockets are both expensive and prone to delays. While they might seem like a natural progression, it's not always the best way to continue exploring space. And especially with the SLS, the desire to build the rocket can override any thoughts of why it is being built in the first place.

> "They've proven they can get to space pretty regularly, and I don't see why they can't do a lot more" **Henry Hertzfeld**

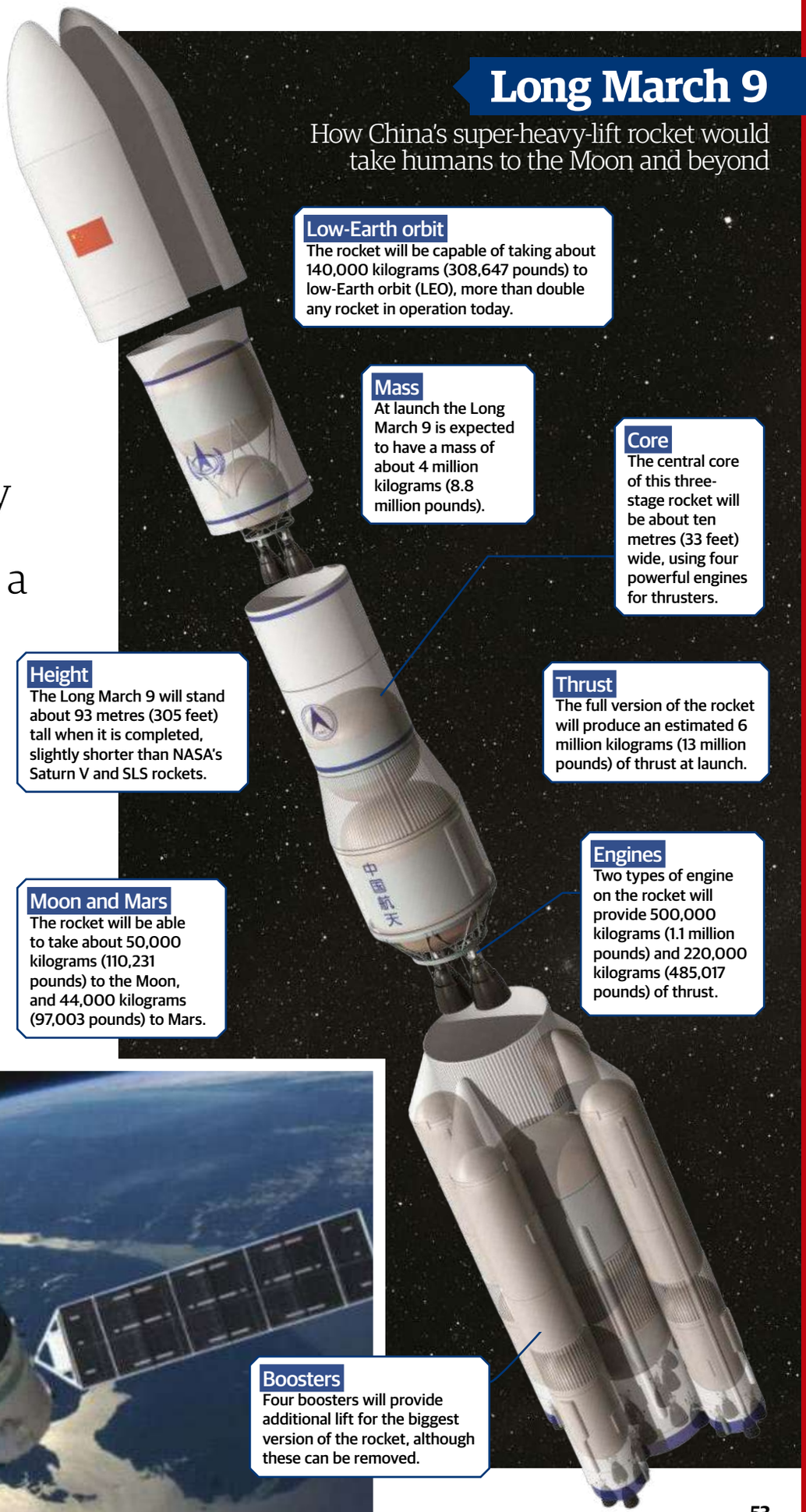
"There's nothing natural about it," Roger Launius, former chief historian of NASA, tells **All About Space**. "You have to ask the question, what's the point of this investment? And everybody's had that problem. That includes the nation states who want to do these things all the way down to the entrepreneurs like Elon Musk and Jeff Bezos."

SpaceX has found something similar with its Falcon Heavy rocket, which launched for the first time in February 2018. That inaugural launch carried nothing but Elon Musk's own Tesla Roadster

China's prototype space station Tiangong-1 crashed back to Earth in April 2018

Long March 9

How China's super-heavy-lift rocket would take humans to the Moon and beyond



Low-Earth orbit
The rocket will be capable of taking about 140,000 kilograms (308,647 pounds) to low-Earth orbit (LEO), more than double any rocket in operation today.

Mass
At launch the Long March 9 is expected to have a mass of about 4 million kilograms (8.8 million pounds).

Core
The central core of this three-stage rocket will be about ten metres (33 feet) wide, using four powerful engines for thrusters.

Height
The Long March 9 will stand about 93 metres (305 feet) tall when it is completed, slightly shorter than NASA's Saturn V and SLS rockets.

Thrust
The full version of the rocket will produce an estimated 6 million kilograms (13 million pounds) of thrust at launch.

Engines
Two types of engine on the rocket will provide 500,000 kilograms (1.1 million pounds) and 220,000 kilograms (485,017 pounds) of thrust.

Moon and Mars
The rocket will be able to take about 50,000 kilograms (110,231 pounds) to the Moon, and 44,000 kilograms (97,003 pounds) to Mars.

Boosters
Four boosters will provide additional lift for the biggest version of the rocket, although these can be removed.

Yang Liwei became China's first human to go to space in 2003

"You've got to make sure everything works right. There are big powerful engines, and things go wrong" **Henry Hertzfeld**

car into space, a publicity stunt on Musk's behalf that intended to show in part how different SpaceX was compared to its stuffier national counterparts. But it also had a somewhat undesired effect of demonstrating there is little desire for such a heavy booster. The Falcon Heavy has a handful of upcoming launches planned, but already it is facing a dwindling market as satellites become smaller, and launch costs become cheaper – by their own design, thanks to their reusable Falcon boosters. It highlights, though, that while China appears to be going ahead with this new rocket, there is little market for one super-heavy-lift rocket, let alone three if the SLS and BFR also reach completion. Russia has even suggested it may also be looking at getting back into this launch arena.

If China is serious about going to the Moon or Mars, then the rocket might make sense. It could very feasibly be used as part of a plan to build a human lunar research base, which the country has suggested it is looking to build. And they have precedent so far for following through with their convictions, including launching an experimental space station (Tiangong-1) in 2011, sending a rover to the Moon in 2013 and preparing a mission to the far side of the Moon. To support this latter mission, Chang'e 4, they sent a relay satellite to the Moon in May 2018 – again showing they are serious.

"They've proven that they mean it," Henry Hertzfeld, research professor of Space Policy and International Affairs at George Washington University, tells **All About Space**. "If they want to put another space station up or go to the Moon then sure, the bigger the rocket the more stuff you can carry up and go further. They've proven they can get to space pretty regularly, and I don't see why they can't do a lot more. They have a different type of government and if they decide to do something, they do it."

When it comes to funding that's especially true, as it appears China are more willing than their US counterparts to put their money where their mouth is. NASA has struggled with delays and funding for its SLS rocket, with the launch date slipping from 2018 to most likely 2020. But if the Long March 9 rocket gets approved – which hasn't happened officially just yet – then things might progress rather more smoothly. "Every five years they come out with a plan, and they follow it," says Hertzfeld.

That being said, it's not clear how much the Long March 9 will cost. Very little is known about how much China spends on its space programme, with even less known about how much they intend to spend on this rocket. But considering they are one of only two nations in the world – the other being Russia – that can currently send humans to space, and that they've launched a small space station and have landed on the Moon, it's probably safe to assume they are pumping quite a lot of money into space. When their space programmes need money, they appear to find the funding from somewhere. "Rockets aren't cheap," says Hertzfeld. "You've got to have a lot of tests, got to make sure everything works right. There are big powerful engines, and things go wrong. I'm sure it's expensive."

What's clear though is that China is serious about its space ambitions, further solidified by the Long March 9. While the exact need for the rocket is questionable, there's no doubt that they will need something of this size if they truly want to send humans to the Moon and Mars. They'll have no shortage of competitors but, in lieu of international cooperation for political reasons, going it alone is their only option. And given what they've accomplished so far, you wouldn't put it past them being successful. "The Long March 9 could very well help put Chinese astronauts on the Moon," said Jones. And who knows what might be next.

China is hoping to match the reusability of SpaceX's rockets

ENCEL

A NEW PLACE FOR LIFE?

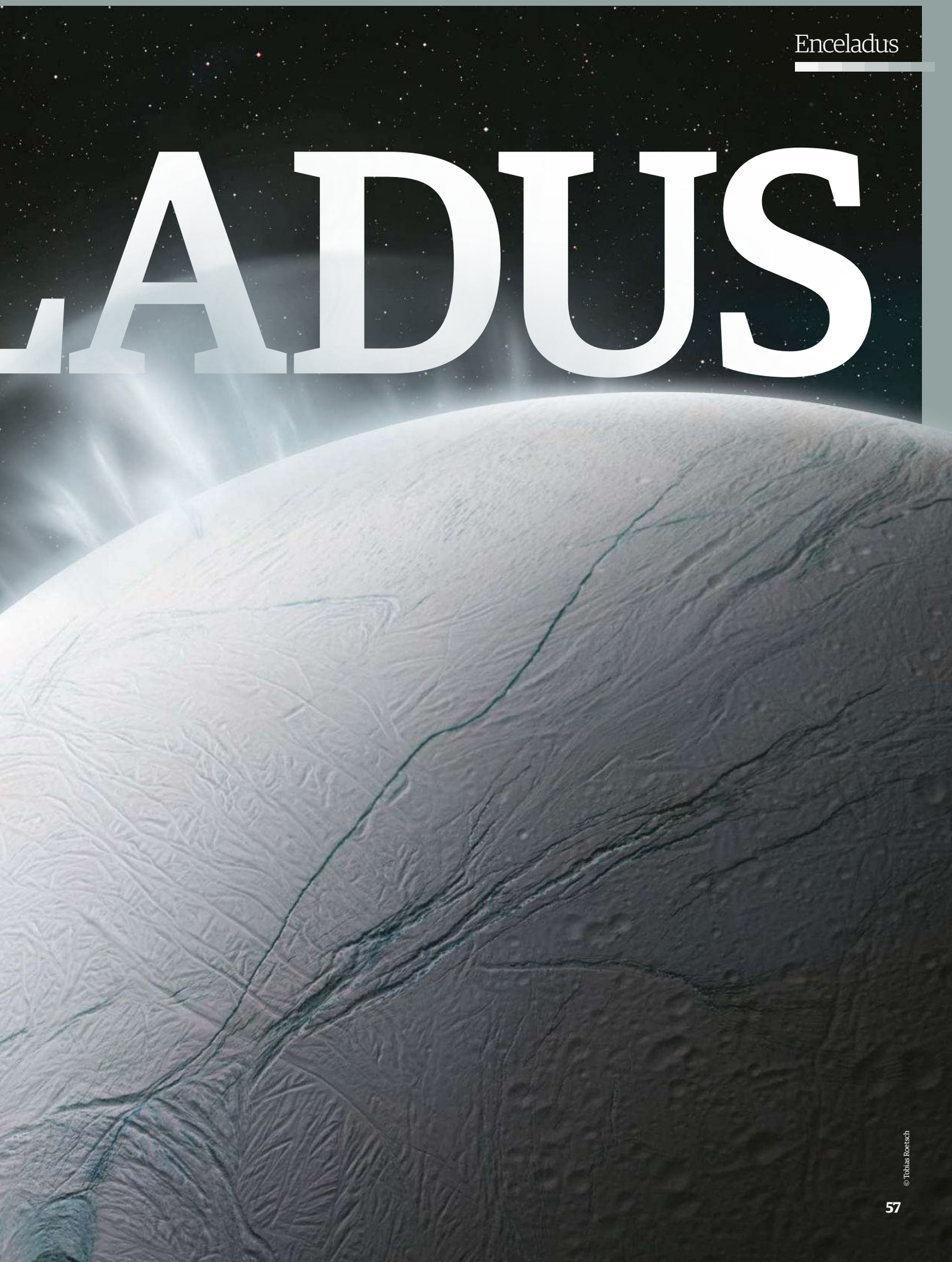
Forget Mars, this frozen member of Saturn's family of moons could hold the key to organisms beyond the confines of Earth

Reported by Lee Cavendish

Enceladus is Saturn's sixth-largest moon and a world that is seven-times smaller than our natural satellite. It orbits Saturn at around 1.2 billion kilometres (746 million miles) away from Earth and reflects nearly 100 per cent of the sunlight that hits its surface. Very little was known about this icy world but that changed when NASA's Cassini spacecraft performed its first flyby of Enceladus and imaged its south pole. This revealed plumes of ice and water vapour erupting into space, and Cassini returned about 2.5 years later on 12 March 2008.

This was when scientists realised that this moon has a hidden, rich and surprising interior that could make it a keen target for astrobiological study. Now it is considered one of the – if not *the* – most exciting prospects for extraterrestrial life and a potentially habitable environment elsewhere in our Solar System. "As the evidence continues to grow, Enceladus becomes a more and more attractive candidate to look for life. For me, Enceladus is the most likely place to look for life beyond Earth," Dr Linda Spilker, the project scientist for Cassini, explains to **All About Space**.

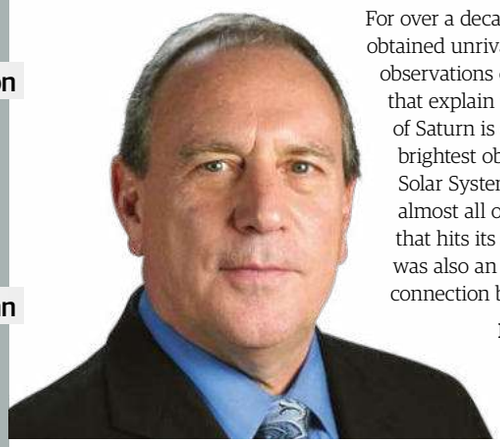
LADUS



Small Solar System size comparison

Over a decade later, scientists have recently been reanalysing the data collected by the Cassini spacecraft. This study has discovered that the molecules that constitute these erupting space plumes are more complex and exciting than previously thought. Courtesy of Cassini's two scientific instruments, the Cosmic Dust Analyzer (CDA) and the Ion and Neutral Mass Spectrometer (INMS), the identification of these complex, carbon-rich organic molecules now tick another box when it comes to the criteria of the requirements for life.

"Enceladus checks all the boxes for habitability: liquid water, organic material for use as building blocks and a source of chemical energy. Furthermore, the material vented into space from its ocean provides an easy means to investigate the ocean below," Dr Hunter Waite of the Southwest Research Institute in San Antonio, Texas, United States and also principal investigator of Cassini's INMS instrument, tells **All About Space**. "Europa [Jupiter's fourth largest moon] may be just as interesting from an astrobiological perspective, or more so, but we do not have the data to draw that conclusion yet. Given our present state of knowledge, Enceladus is the most practical place to look for extant life outside of Earth."



Dr Hunter Waite is the principal investigator of the INMS instrument

For over a decade, Cassini obtained unrivalled observations of Enceladus that explain why this moon of Saturn is one of the brightest objects in the Solar System, reflecting almost all of the sunlight that hits its surface. There was also an unknown connection between the moon and Saturn's E-ring which needed to be answered as well. When Cassini arrived at the scene in 2005, its suite of finely tuned instruments and equipment had the ability to resolve the unexpected icy water jets spewing out from the 'tiger-stripes' surface features at the south pole of Enceladus from afar. Cassini also had the ability to fly through these plumes, gathering unique data about them and revealing a mixture of volatile gases, water vapour, carbon dioxide and carbon monoxide, as well as organic materials. The density of organic materials was about 20-times denser than expected.

Astronomers back on Earth have been thoroughly examining the data over the course of this mission. Early analysis of Enceladus' plumes revealed the presence of a subsurface ocean about ten kilometres (six miles) deep beneath an ice shell about 30 to 40 kilometres (19 to 25 miles) thick. There was also evidence for the presence of hydrothermal vents, which are cracks on the planet's core releasing heat, residing at the bottom of its ocean. Scientists are certain this is due to the intense gravitational pull of Saturn acting on Enceladus.

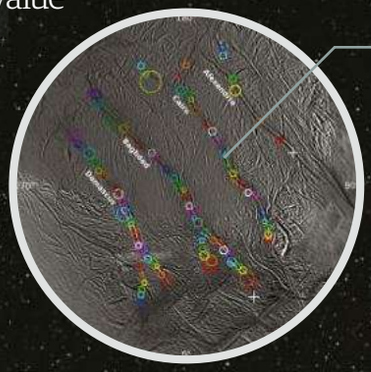
In the same way the Earth exerts a gravitational pull on the Moon to keep it in orbit, the Moon also exerts a gravitational pull on Earth. The gravitational pull of the Moon is what provides us with tides, and as Enceladus is much smaller than the Moon and Saturn is much more massive than Earth, Saturn's gravitational effect on Enceladus is much more dominant. The effect is actually so intense that Enceladus' interior is heated up through the friction of the continuous pulling and pushing on its interior due to Saturn's gravity. This effect is known as 'tidal heating' and it is the cause of the moon's interior hydrothermal vents and what stops the ocean turning into a frozen, barren world.

Now this new study has discovered another fascinating fact about Enceladus which has ramped up the excitement surrounding it, even after Cassini's demise in September 2017. A recent study led by Dr Frank Postberg of the University

Cassini completed 23 flybys of Enceladus and several deep dives into its plumes

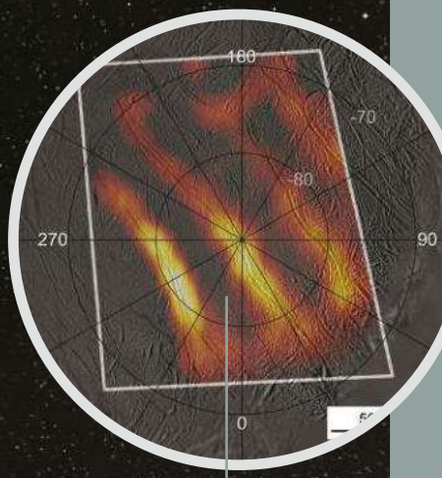
What's happening at Enceladus?

With the recent discovery of complex building blocks for life, understanding what Cassini learned about this small, icy world holds great value



100 geysers on Enceladus

This stereographic map plots the 100 geysers of water and ice shooting out of the moon's four main surface fissures from its south pole.



Heat mapping

This heat map of the south pole was taken using Cassini's Composite Infrared Spectrometer (CIRS). It shows the temperature drastically increases in the tiger stripes.

Geysers erupting

Cassini flew through these plumes at an altitude of roughly 200 kilometres (124 miles) to reveal they are made up of complex organic molecules, water vapour, volatile gases, carbon dioxide and carbon monoxide.

Fractures in the surface

The four prominent fractures in the south pole, the 'tiger stripes', provide the path for the interior contents and heat to escape. This is where the bubbles burst and the organic substances are released.

Subsurface ocean

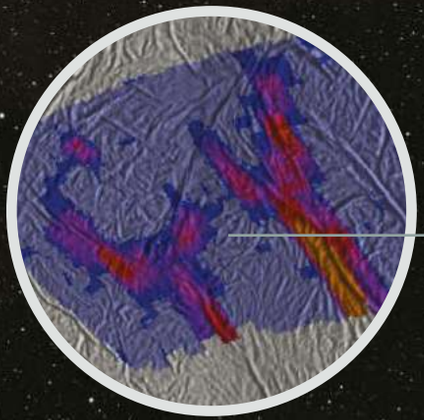
This ocean is believed to to be ten kilometres (six miles) thick, and is believed to transport the organics on the walls of bubbles effervescing from the hydrothermal vents.

Tiger stripes

These blue stripes on the surface are the cracks made by Enceladus' interior-heated ocean seeping through and erupting.

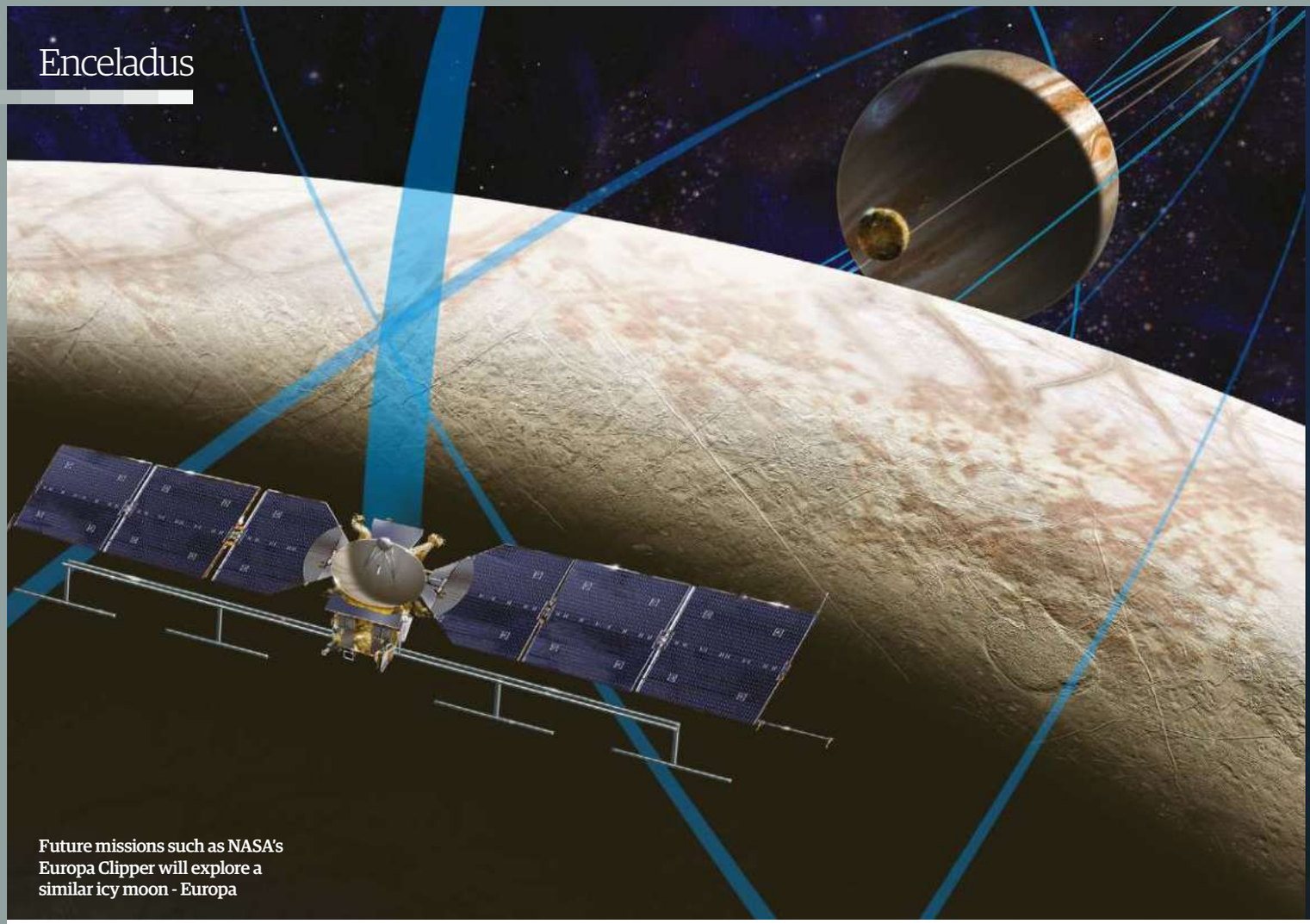
Heated rocky core

Tidal heating leads to a build-up of heat in the core of Enceladus, and as a result hydrothermal vents are formed on the face of the core and expel the heat necessary to power the plumes.



Two of the stripes

The two fissures, Cairo Sulcus on the left and Alexandria Sulcus on the right, show a different type of high-resolution thermal map.



Future missions such as NASA's Europa Clipper will explore a similar icy moon - Europa

"Enceladus checks all the boxes for habitability: liquid water, organic material and a source of chemical energy" **Hunter Waite**

of Heidelberg, Germany, has identified incredibly complex organic molecules with masses over 200 atomic mass units, which is more than ten-times heavier than methane. "This is the first ever detection of such complex organics coming from an extraterrestrial water-world, but we do not know if the organics we found are of biogenic origin or in any way connected to life," explains Postberg. "Indeed, complex organics do not necessarily provide a life-friendly environment. On the other hand any life as we know it, and even any prebiotic chemistry, requires complex organic molecules."

This discovery comes as a result of two of Cassini's 12 on-board scientific instruments. The CDA and INMS are both mass spectrometers that were hit by ice grains at speeds of around 30,000 kilometres (18,641 miles) per hour. With each impact the ice grains were broken up and the instruments were able to take a look at the fragments that remained. "We can then analyse these fragments and compare them to related laboratory experiments to draw conclusions about the chemical nature of these organics. How the molecules break apart provides information on the elements present and the nature of the molecular structure," says Waite.

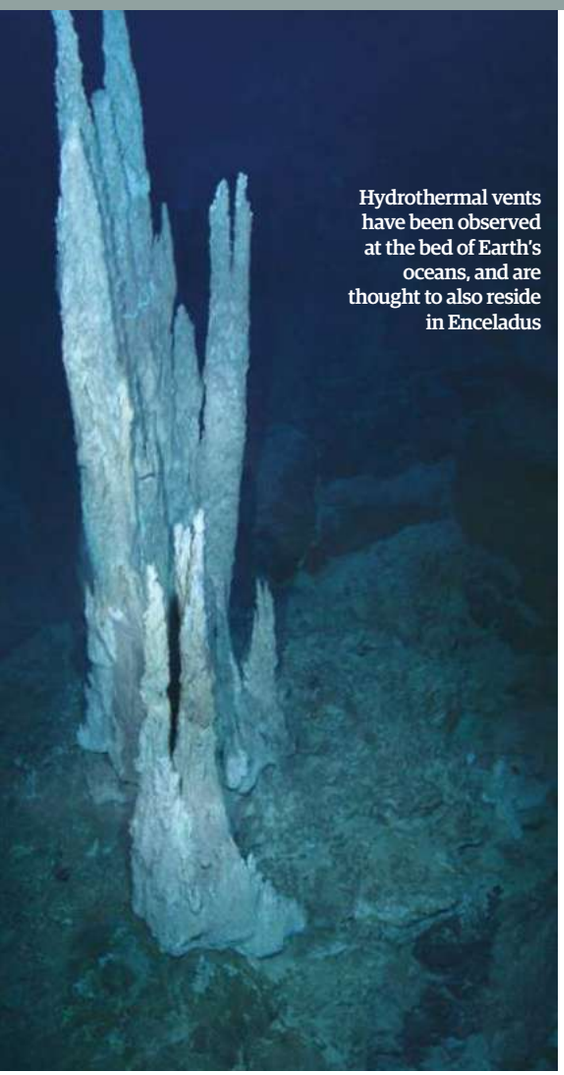
It seems like Enceladus is quite hydra-headed in terms of that when one question gets answered, three more enter in its place. Although scientists have been able to identify the complexity of molecules present at the distant water-world, now there are questions over how they are formed, what this tells us about the moon's potential habitability and if there are any forms of life residing there at this present time.

"In principle there is a wide range of possibilities [for how these molecules formed]. Such large molecules can only be created by complex chemical processes – including those related to life," explains Postberg. "Alternatively they could come from primordial material as found in some meteorites or, more likely, be generated by hydrothermal activity."

There are three main possible explanations as to how these carbon-rich molecules have come about, and all three are positive signs for life on Enceladus in their own way. One scenario is that these are primordial pieces of carbonaceous material that have been released due to the thermal evolution of the moon. The other is that these complex organics are the combination of simpler carbon materials that are formed on the aforementioned hydrothermal vents, or it is even possible that this is the refuse of living organisms. The first two abiotic scenarios are positive for a sign of life, as it means that there is a fuel source being created for any potential organisms. The last scenario, however, could mean that there is, or has previously been, a form of life at Enceladus. When asked about what type of life form could be at Enceladus, Waite replies that "life on Enceladus would likely be single-celled microbes, similar to the most primitive forms of life on Earth, such as methanogens."

In order to get to the bottom of how these organics turn up in such an environment, particularly as there is no spacecraft there at the moment, scientists require much more extensive theoretical models and laboratory experiments. How they're formed is relatively unknown, but how they find their way to the Cassini instruments is by hitching a ride on the surface of bubbles. "After entering the ocean the organics can be transported upwards to the ocean surface on the walls of rising bubbles of gas," says Postberg. "When reaching the ocean surface, the organics form a layer or film there."

However, even with all the questions that have surfaced courtesy of this detection of complex molecules, it has been more promising than Mars when it comes finding organic compounds. Postberg makes a point that "The most intriguing difference is how easily one finds complex organics on Enceladus compared to Mars. If you consider the enormous efforts put into the search for organics on Mars since the 1970s without success, it is just amazing how easily we found a complex and



Hydrothermal vents have been observed at the bed of Earth's oceans, and are thought to also reside in Enceladus

diverse organic chemistry on Enceladus just with a spacecraft flying by."

Mars has had numerous amounts of orbiters, landers and rovers searching for signs of life since the Mariner 9 became the first spacecraft to orbit Mars in 1971. The search for life on Mars is an idea that has been the driving force behind many Martian exploration missions, and scientists have since been finding evidence of ancient organic compounds. The most recent discovery is NASA's Curiosity rover drilling into a 3-billion-year-old sedimentary rock at the Gale Crater and finding 'tough' organic compounds. Curiosity's Sample Analysis at Mars (SAM) instrument found large, carbon-based, organic compounds that also include sulphur. Sulphur was not discovered at Enceladus, but this is because the instruments are not sensitive enough to detect sulphur. It could be the case that sulphur is present at Enceladus but it hasn't been detected, meaning the dry Red Planet and distant water-world moon could be very similar in terms of organic compounds. Mars is now considered an inhospitable world with no atmosphere, meaning that the Sun's unfiltered rays can rain down on the unprotected surface and evaporate any water. This makes it extremely hard for any form of life to survive in this difficult terrain. Now evidence has come to light of organic compounds at a more favourable environment, scientists will need to start looking at moons with interior oceans such as Enceladus, Europa, Ganymede and Callisto more extensively.

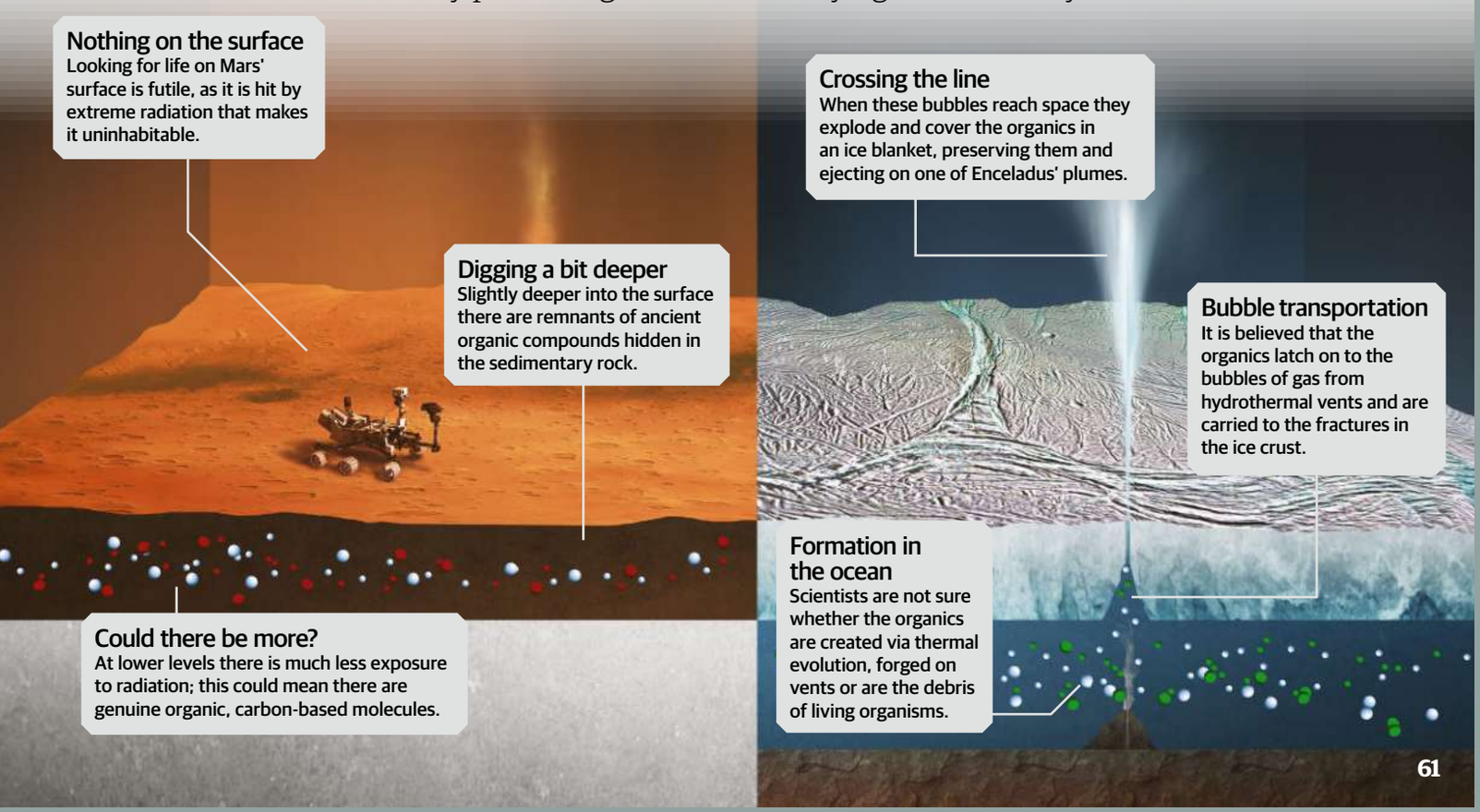
Unfortunately, the future exploration of Enceladus is looking bleak, as there is no spacecraft commissioned to go back to the Saturn system, and in particular Enceladus. When you reflect on the amazing discoveries that Cassini made with a collection of instruments that weren't designed for examining this unique world, as they were built before scientists knew about Enceladus' activity, imagine what astrobiologists and planetary scientists could learn from a spacecraft that was specifically made for studying the moon.

"There will probably be new Enceladus mission proposals for the next NASA New Frontiers call. A future Enceladus mission could consist of a series of flybys of Enceladus, similar to the Europa Clipper mission, or perhaps the spacecraft will go into orbit around Enceladus," says Spilker. "Any future Enceladus missions will probably carry instruments to search for evidence of life and to better characterise the habitability of the ocean."

With the advancements in technology and the innovative new techniques astronomers come up with each day, a pioneering orbiter – which could even include a lander to grace the surface – would unveil unbelievable results about Saturn's shining moon. It appears that the major space organisations such as NASA and the European Space Agency are convinced that Europa would be the better target, as it also exhibits signs of an interior ocean. However, with the data Cassini collected and the new discoveries that we continue to learn from it, a return to Enceladus is imminent.

Organics head-to-head: Mars vs Enceladus

Two different terrains have both exhibited signs of organic compounds, which is an extremely positive sign for scientists trying to find life beyond Earth



Postcards from the Solar System

Spacecraft working tirelessly around and on other worlds check in to send back the most recent snapshots of unimaginable imagery

JAXA

26 June 2018 • 7:03pm (UTC)

Welcome to Ryugu

AllAboutSpace Hayabusa2 is an asteroid sample-return mission operated by the Japan Aerospace Exploration Agency (JAXA), and it has recently sent back some remarkable pictures as it approaches its target Asteroid 162173 Ryugu. On 25 June 2018, Hayabusa2 snapped this glorious picture of Ryugu using its Optical Navigation Camera – Telescopic (ONC-T), and the spacecraft, after a 42-month journey, safely arrived at Ryugu on 27 June 2018 at 12:35am (UTC).

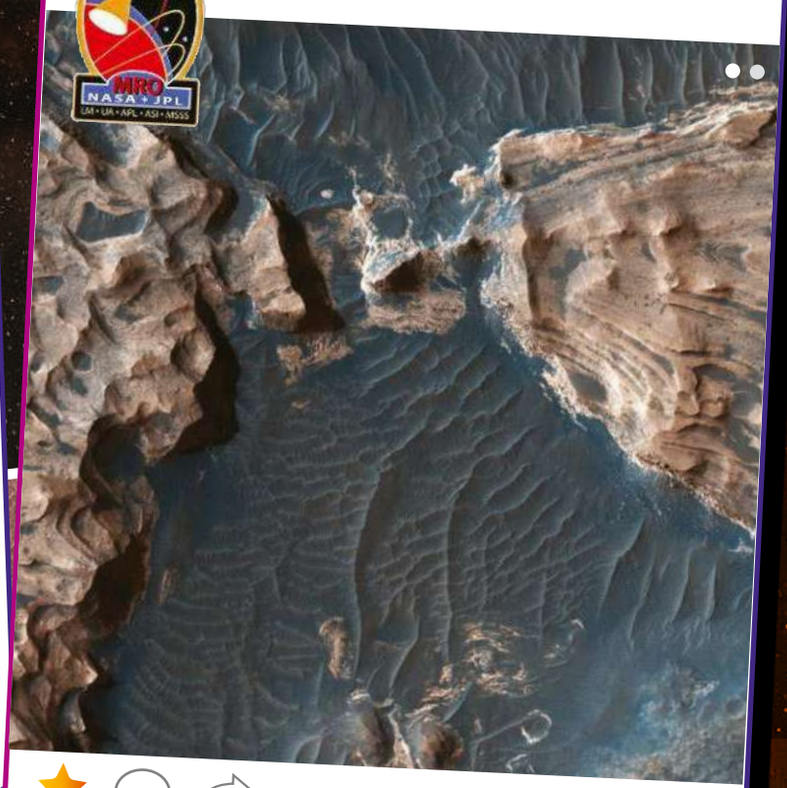
This asteroid is expected to help astronomers uncover the secrets of our past and explain how the early Solar System formed and evolved. The data collected in this mission has already caught the attention of astronomers worldwide, including Queen's lead guitarist and astrophysicist Dr Brian May. May's stereoscopic images of Ryugu have been superimposed in red and blue, which will make the image appear 3D with the help of the correct stereo glasses.

#Ryugu #Hayabusa2 #JAXA #AllAboutSpace #PostcardsFromTheSolarSystem

"The shape of Ryugu [was] revealed. Ryugu, which initially looked round from the distance, turned gradually into a square and it was a beautiful shape like a firefly stone as it got closer"

Yuichi Tsuda – Hayabusa2 project manager

NASA/JPL



1 April 2018 / 13 May 2018 • 3:24pm / 4:43pm (Local Mars Time)

Mars from above

AllAboutSpace NASA's Mars Reconnaissance Orbiter (MRO) is a conveyer belt of fantastic birds-eye pictures of the Martian terrain. Its most recent snaps are these two pictures of the Aram Chaos (above), a 280-kilometre (174-mile) diameter impact crater created over 2.5 billion years ago, and the south pole of Mars (left), showing blotches of spider-esque surface features.

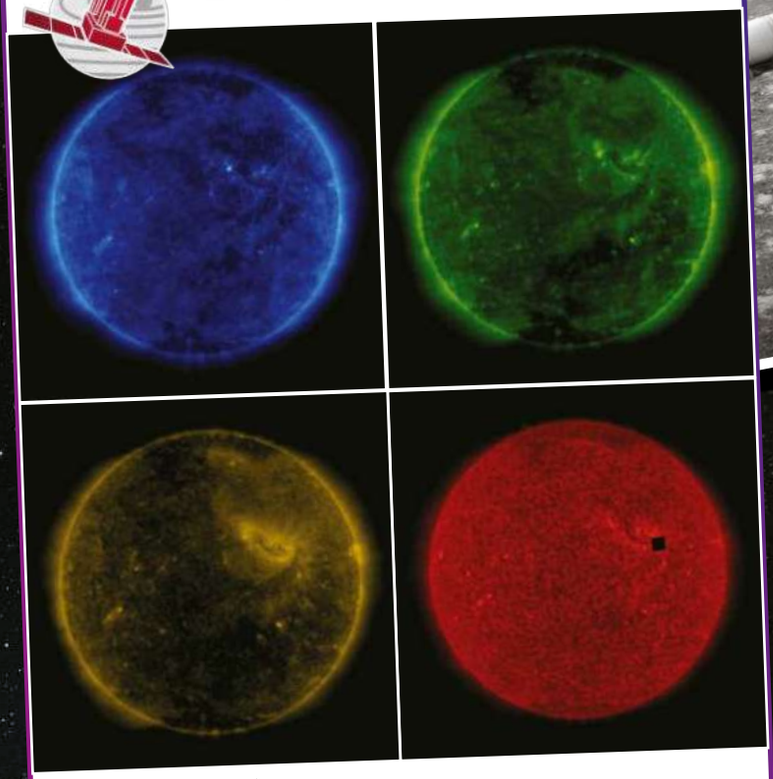
The MRO uses its excellent High Resolution Imaging Science Experiment (HiRISE) camera to carefully examine the land down below. Examining craters like the Aram Chaos can reveal their past, such as how this crater once held a lake based on its colour contrast and the appearance of minerals altered by water. The south pole's 'spiders' are in fact radiating mounds that form when carbon dioxide heats up and escapes, which tells astronomers about the physical processes going on in active seasonal cycles.

#Mars #MRO #NASA/JPL #AllAboutSpace #PostcardsFromTheSolarSystem

"It's a marvellous vehicle [MRO] that we expect will serve the Mars Exploration Program and Mars science for many more years to come"

Dan Johnston – MRO project manager

ESA/NASA



25 July 2018 • 1:00 (blue) / 1:13 (green) / 1:06 (yellow) / 1:19am (red) (UTC)

Eyes on the Sun

AllAboutSpace At the orbital parking spot known as Lagrange point 1 is the Solar and Heliospheric Observatory, or SOHO. This point is approximately 1.5 million kilometres (932,057 miles) from the Earth, and provides an uninterrupted view of our star. The spacecraft is equipped with instruments that are specially made to watch the Sun in order to understand space weather, which is the expulsion of highly energetic particles into circumstellar space. These particles have the potential of interfering with life on Earth.

At the moment the Sun is fairly inactive as it is reaching its solar minimum in terms of its activity. These four recent views of the Sun have been imaged using SOHO's Extreme ultraviolet Imaging Telescope (EIT), which can observe in different wavelengths. Here all show relatively no sunspots. The blue Sun was created by EIT 171, the green by EIT 195, the yellow by EIT 284 and the red by EIT 304. The numbers correspond to the wavelength, in ångströms, that the Sun is being observed in.

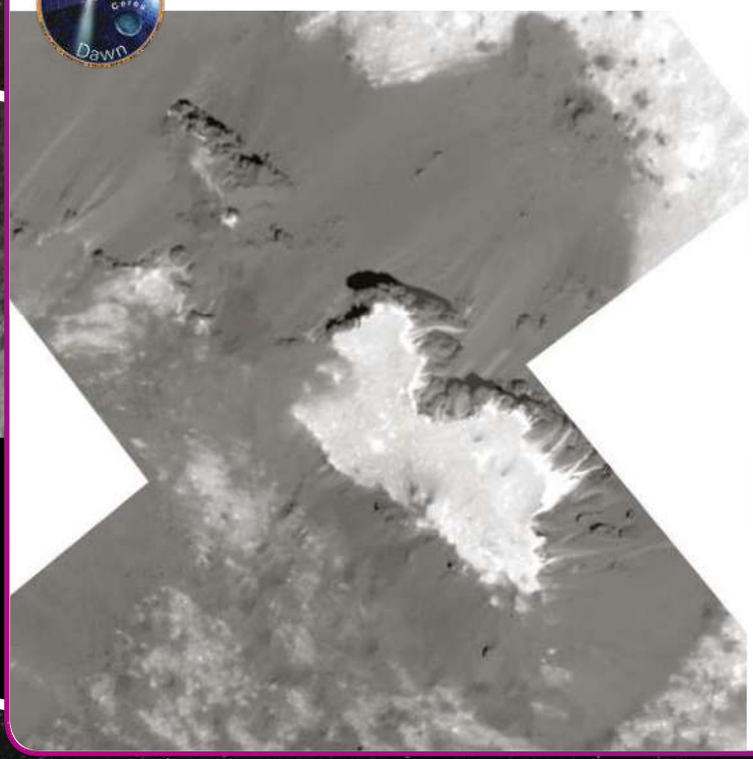
#Sun #SolarActivity #ESA #NASA #SOHO #PostcardsFromTheSolarSystem

"SOHO is recognised as a unique resource that is critically important for space weather research and improved space weather predictions"

Dr Bernhard Fleck – SOHO project scientist and mission manager

NASA/JPL

NASA/McREL



15 June 2018 • Combines images taken between 7:15 and 8:15am (UTC)

Snapping a selfie on Mars

AllAboutSpace NASA's Curiosity rover has always been partial to a selfie, and in this case the Mars-based rover wanted to show just how dusty it was. Two weeks prior to this self-portrait a dust storm began encompassing Mars, and eventually growing larger than North America and Russia combined if it were on Earth. This storm led to Curiosity's rover companion, the nearly 15-year-old solar-powered Opportunity rover, having to suspend science operations and place itself in a low-power safe mode on 10 June. It's thought that the storm is now starting to clear but it could take weeks, or possibly months, for Opportunity to phone home.

However, on the other side of Mars the nuclear-powered Curiosity was busy taking this self-portrait with its Mars Hand Lens Imager (MAHLI), which shows the rover at a drill sample site (a 1.6-centimetre (0.6-inch) drill hole can be seen to the left of Curiosity), known as 'Duluth', on Mount Sharp.

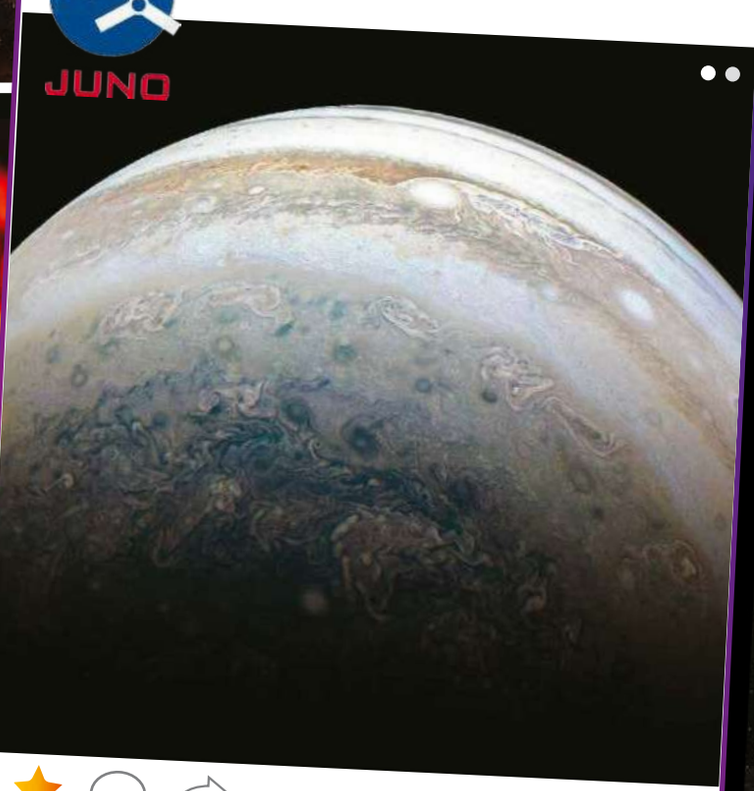
Tom Green – systems engineer at NASA's Jet Propulsion Laboratory (JPL), Pasadena, California, United States: "We've been developing this new drilling technique for over a year, but our job isn't done once a sample has been collected on Mars."

#Mars #Curiosity #Selfie #MarsScienceLaboratory #RedPlanet #AllAboutSpace #Horizon #MartianRock #Space #PostcardsFromTheSolarSystem

"The new Io hotspot JIRAM picked up is about 200 miles [300 kilometres] from the nearest previously mapped hotspot"

Alessandro Mura – Juno co-investigator from the National Institute for Astrophysics in Rome, Italy

NASA



24 May 2018 • 6:31am (UTC)

From Jupiter with love

AllAboutSpace NASA's Juno spacecraft has been at Jupiter since 4 July 2016, and the photos and data it has been sending back to Earth have been keeping astronomers busy ever since. With each new flyby the instruments have an limited timeframe to collect data, and in the most recent flyby the instruments got to work for the 13th time. The JunoCam was able to take a picture of Jupiter from a unique angle that shows off its tempestuous storms at the southern hemisphere, 71,400 kilometres (44,300 miles) above Jupiter's cloud tops.

Using its Jovian Infrared Auroral Mapper (JIRAM) instrument Juno also found a new heat source emanating from the surface of the Galilean moon Io. This strongly points to the idea that a new volcano has been discovered on the fiery moon's surface.

#Jupiter #Juno #NASA #AllAboutSpace #SolarSystem #Auroral Mapper #PostcardsFromTheSolarSystem

22 June 2018 • Time unpublished

From dusking Ceres to Dawn

AllAboutSpace As NASA's Dawn spacecraft approaches the final moments of its 11-year mission, including its mission around the small, icy dwarf planet Ceres, it continues to explore Ceres' unusual surface features. Dawn – the only spacecraft to orbit two deep-space destinations – is expected to run out of fuel, sometime between August and October, when it will cease communication with Earth, but will remain in orbit around Ceres.

This mosaic was obtained by Dawn from an altitude of about 34 kilometres (21 miles) where Dawn photographed two of the dwarf planet's most famous features: the Cerealia Facula and Occator Crater. Images such as these, along with other spectrometry measurements, have revolutionised our understanding of Ceres, revealing deposits of sodium carbonate and its broader composition at a finer scale. It is also thought that the dark background may hold clues about the origins of the facula.

Dr Carol Raymond – Dawn's deputy principal investigator: "The first views of Ceres obtained by Dawn beckoned us with a single, blinding bright spot."

#Ceres #Dawn #NASA #AllAboutSpace #DwarfPlanet #PostcardsFromTheSolarSystem

HOW TO TRAVEL FASTER THAN LIGHT

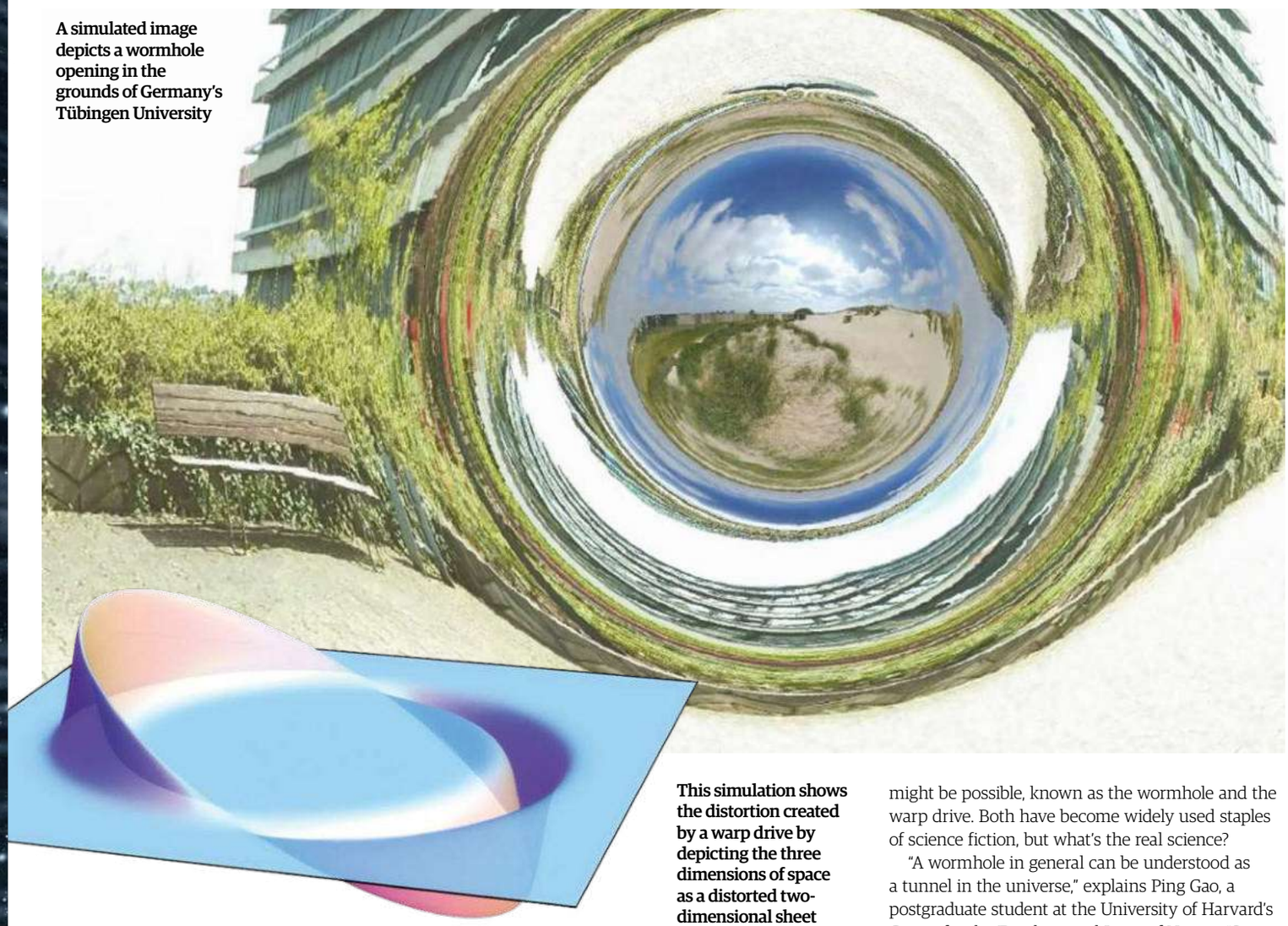
The laws of physics say that nothing can break the cosmic speed limit – but are there ways of bending the rules?

Reported by Giles Sparrow

EL STER LIGHT

Our universe is big – so big that we measure cosmic distances in terms of light years, the distance that light, the fastest thing in the universe, travels in a year. Light travels at almost 300,000 kilometres (186,411 miles) per second, which means that a light year is equivalent to about 9.5 trillion kilometres (5.9 trillion miles). Even the closest stars are several light years away, while our own Milky Way galaxy is around 100,000 light years across.

If humans ever hope to explore beyond the cosmic backyard of our Solar System we'll somehow have to overcome the enormous challenge these distances represent. So far it's taken decades for our most distant space probes to travel just a few light hours to the edge of our Solar System, just a few billion kilometres away. Getting anywhere close to light speed will require sources of propulsion entirely different from traditional chemical rockets, and perhaps ways completely unknown to present-day engineers.



A simulated image depicts a wormhole opening in the grounds of Germany's Tübingen University

This simulation shows the distortion created by a warp drive by depicting the three dimensions of space as a distorted two-dimensional sheet

The laws of physics hide surprising traps for any spacecraft daring to even approach the speed of light. One of these lies hidden in the famous equation $E=mc^2$. This relationship, described by Albert Einstein in his 1905 Theory of Special Relativity, shows that the overall energy of an object (E) is related to both its mass (m) and the speed of light (c). Accelerating an object increases its overall energy, but as the object approaches 'relativistic' speeds something surprising happens – more and more of the energy goes not into boosting the object's speed, but instead into increasing its mass. This in turn makes the object harder to accelerate further. Boosting an object with mass to the speed of light itself takes an infinite amount of energy, as the object itself becomes infinitely massive.

In contrast, a second consequence of relativity could make life slightly easier for potential interstellar travellers. An effect called time dilation means that time on board a spacecraft moving at relativistic speeds passes more slowly than it does for 'stationary' objects in the outside universe – accelerate a spacecraft to high enough speeds and its crew could make a 1,000-year journey in what, from their point of view, would feel like a few months. The big catch, of course, is that time dilation is a one-way trip into the future.

So far as we know the speed of light is an inescapable natural speed limit – there's no way for any object with mass to reach it, let alone achieve faster-than-light (FTL) travel. But what if there was a shortcut – a way of bending the laws of physics rather than breaking them – to reach distant parts of the universe in a much shorter period of time?

As it happens, engineers and astronomers have identified not one, but two ways in which this might be possible, known as the wormhole and the warp drive. Both have become widely used staples of science fiction, but what's the real science?

"A wormhole in general can be understood as a tunnel in the universe," explains Ping Gao, a postgraduate student at the University of Harvard's Center for the Fundamental Laws of Nature. "So literally it should have two ends connecting two distant regions in the universe. The wormhole was originally referred to as the 'Einstein-Rosen bridge', which is a special mathematical solution of the vacuum Einstein equation [part of the so-called 'field equations' that describe how the three dimensions of space combine with time to create four-dimensional space-time]."

"If the path through a wormhole is shorter than that through ambient space, we can utilise it as a shortcut through space-time. This is just like a wormhole on an apple making a worm go from one point to the other faster than creeping on the surface of the apple. From an outside point of view travel through a wormhole is just like FTL, but in local terms the traveller never travels faster than light inside the wormhole."

We're familiar with black holes, of course, as the fearsome gravitational whirlpools created when the cores of massive stars collapse at the end of their lives. While a black hole's matter collapses to a tiny but infinitely dense point called the singularity, its outer edge is defined by the event horizon, the region where its gravity becomes so strong that not even light can escape. "The two black holes are connected behind and near their horizons, which is

"A wormhole can be understood as a tunnel in the universe... literally two ends connecting two distant regions" **Ping Gao**

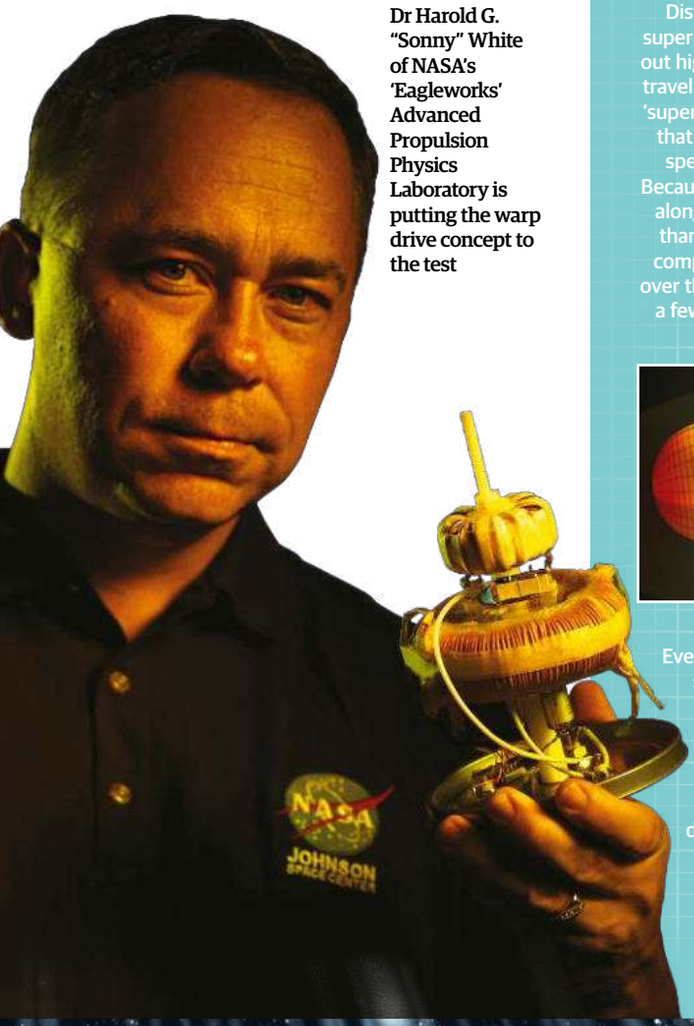
far from the singularity," explains Gao. "This means the region around the Einstein-Rosen bridge is made from curved but smooth space-time."

The fact that the bridge lies beyond the event horizon means that any spacecraft hoping to use it as a shortcut across the universe would still have to reach an impossible, faster-than-light speed in order to enter one black hole and emerge on the other side. Furthermore, the steeply increasing gravity close to the first event horizon would shred the vehicle and its occupants into nothing more than a stream of 'spaghettified' atoms.

There's one final catch. "In general," points out Gao, "a black hole formed by matter collapse does not have any potential to have a wormhole, simply because it only produces one end. If you consider two arbitrary black holes, there is no guarantee of an Einstein-Rosen bridge connecting them."

For all of these reasons, physicists refer to the hypothetical bridges between conventional black holes as 'non-traversable' wormholes. But is there an alternative? In the 1980s Caltech cosmologist Kip Thorne outlined the possibility of a traversable wormhole in which the two ends of the bridge are modified by surrounding them with a shell of so-called 'exotic matter'.

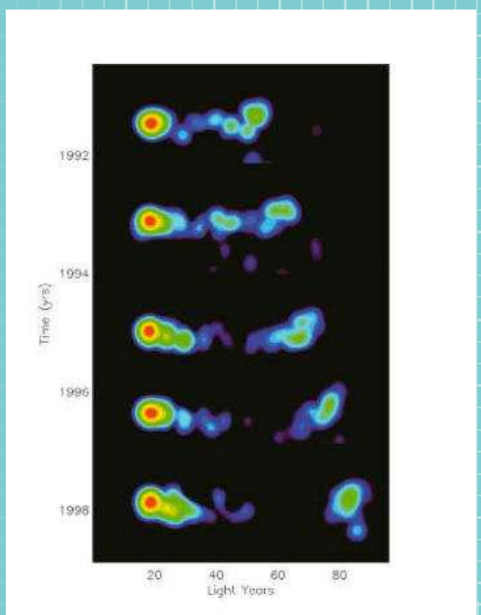
"'Exotic' can be roughly understood as having negative energy," explains Gao. "In classical physics, we do not expect any matter with negative energy, since that would imply negative mass. In quantum physics, however, negative energy on a microscopic scale is easy to find."



Dr Harold G. "Sonny" White of NASA's 'Eagleworks' Advanced Propulsion Physics Laboratory is putting the warp drive concept to the test

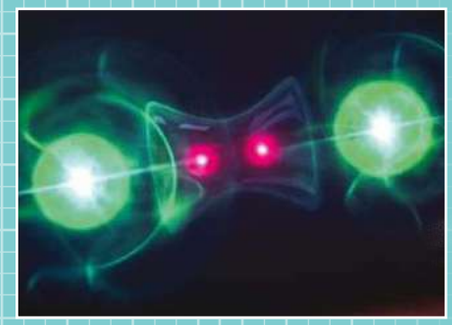
Four things that break the speed limit of the universe

Einstein predicted that nothing with mass can move faster than light but there are objects disobeying the laws of physics



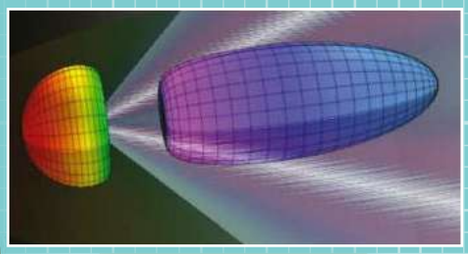
1. Superluminal motion

Distant black holes and active galaxies with supermassive black holes at their hearts can spit out high-speed jets of particles that appear to be travelling faster than light. This form of so-called 'superluminal' motion is in fact an optical illusion that occurs when jets moving at close to light speed are pointing roughly in our direction. Because the radiation emitted at different points along the jet's path is not moving much faster than the jet itself, the train of emitted light is compressed – light emitted at different points over the course of a century reaches Earth in just a few years, creating the impression of faster-than-light motion.



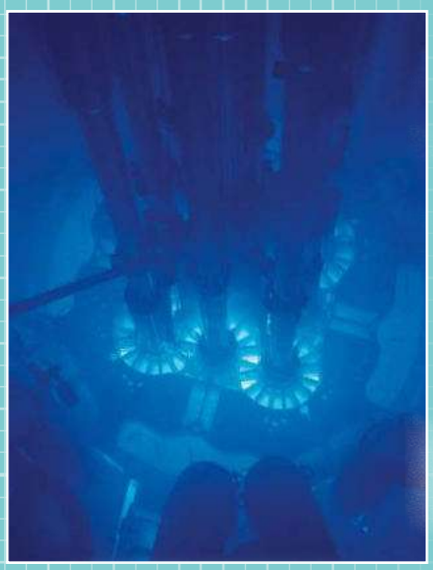
2. Entanglement

In quantum physics, particles with entangled properties remain connected by a strange link however widely they are separated. Measuring and 'resolving' the properties of one causes the other to instantaneously resolve itself in the other direction, with no time needed for a message to travel between them. Einstein called this strange effect "spooky action at a distance" – the laws of physics seem to permit it because it cannot be used to send information at FTL speeds.



3. A tachyonic universe

Even if no particles with mass can travel at the speed of light itself, some physicists have pondered whether there could be a whole universe of particles that travel faster than light. Such particles, known as tachyons, would exhibit a variety of strange properties; for example, their energy would decrease as their speed increased. However, attempts to detect evidence for this strange mirror universe have so far proved unsuccessful.

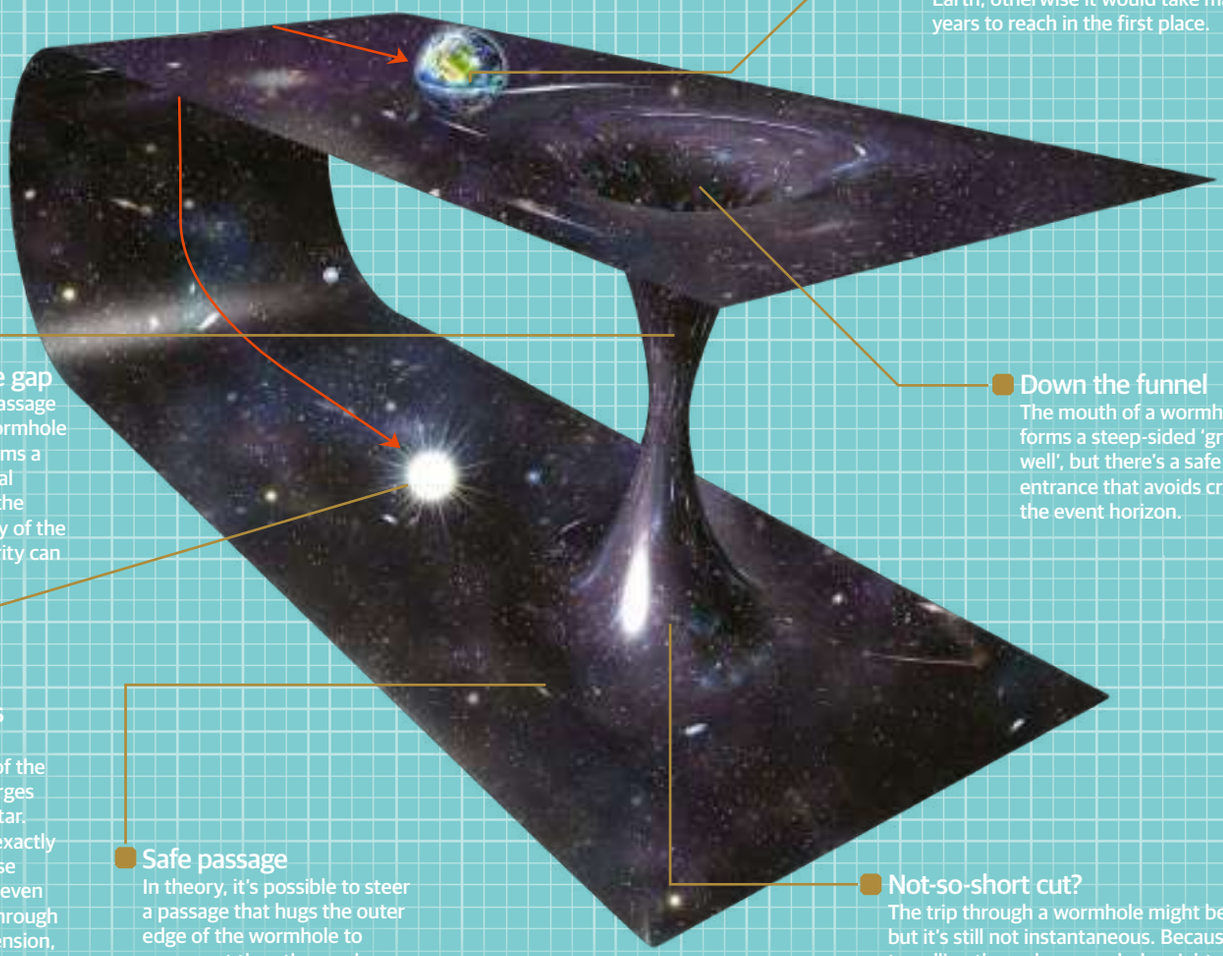


4. Cherenkov radiation

An often overlooked point is that the universe's ultimate speed limit is the speed of light in a vacuum. When light passes through transparent materials it can slow down significantly, and sometimes particles moving through the same medium can break this artificially lowered light-speed barrier. The result is a burst of bluish-coloured Cherenkov radiation – the light equivalent of a 'sonic boom', which can be used to detect high-speed particles such as elusive neutrinos.

Travelling through space and time

Space travel via a wormhole relies on the fact that, according to Einstein's theory of general relativity, the three dimensions of space can be distorted by concentrations of mass, creating curves on large scales



Home near a wormhole
To allow for truly convenient interstellar travel, a wormhole would have to be located (or created) quite close to Earth, otherwise it would take many years to reach in the first place.

Through the gap
Crucially, the passage through the wormhole is 'open' – it forms a broad cylindrical tunnel so that the crushing gravity of the central singularity can be avoided.

Down the funnel
The mouth of a wormhole forms a steep-sided 'gravity well', but there's a safe entrance that avoids crossing the event horizon.

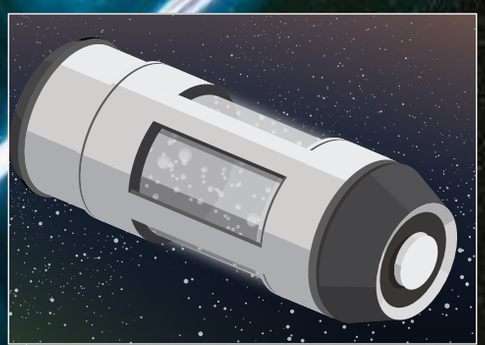
Other places and times?
The other end of the wormhole emerges near a distant star. Depending on exactly how the universe works, it might even form a tunnel through the fourth dimension, time, as well.

Safe passage
In theory, it's possible to steer a passage that hugs the outer edge of the wormhole to emerge at the other end.

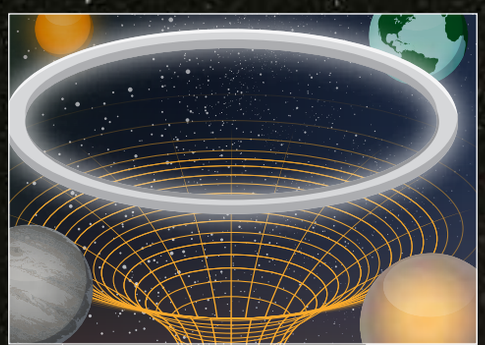
Not-so-short cut?
The trip through a wormhole might be shorter, but it's still not instantaneous. Because travelling through a wormhole might still involve near-light speeds, effects such as time dilation would make the journey seem shorter.

How to build a wormhole

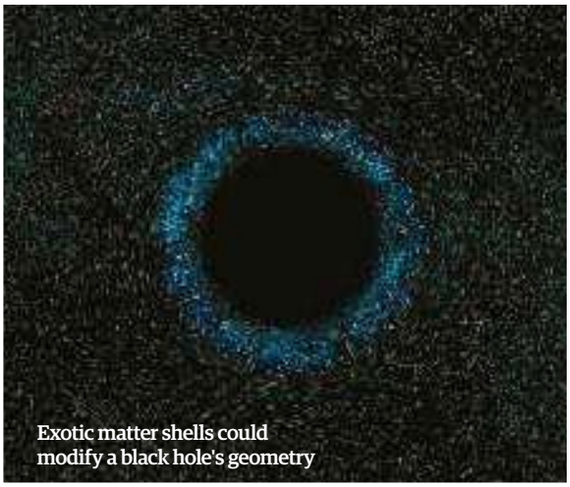
Could we build our own warp gate through space-time?



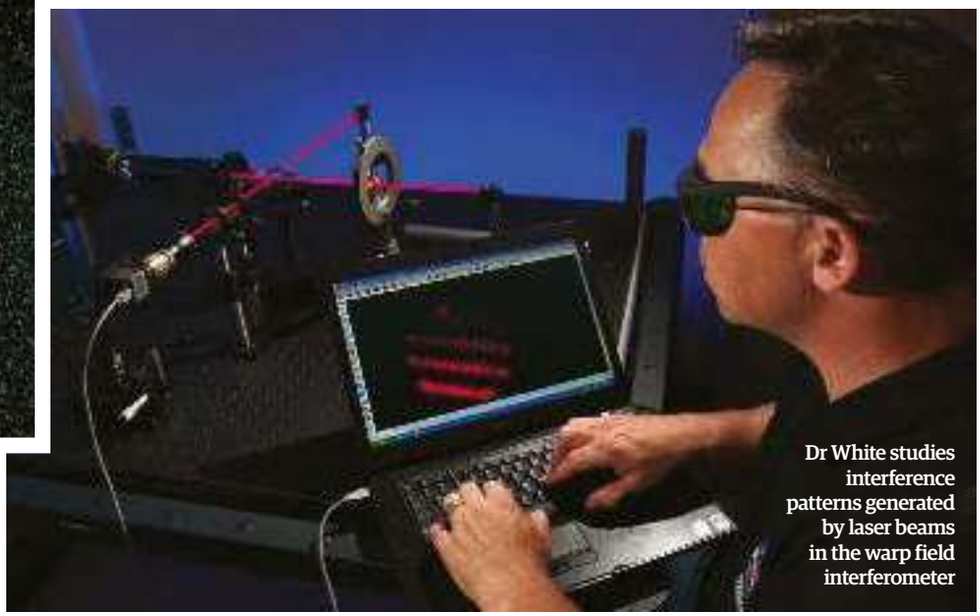
1. Create negative energy
The vital first step towards building a working wormhole would be to understand how to manufacture a source of 'negative energy' on a large scale. Although various forms of negative energy exist, there's no guarantee that a form suitable for building wormholes exists.



2. Find a natural wormhole
The precise types of wormholes that exist depend on cosmology and particle physics. Non-traversable wormholes may link black holes, while microscopic ones may connect entangled quantum particles. An advanced detector would be needed to identify and 'collect' one end of wormhole for manipulation.



Exotic matter shells could modify a black hole's geometry



Dr White studies interference patterns generated by laser beams in the warp field interferometer

Thorne's exotic matter shells would, in theory, modify the geometry of each black hole, bringing the ends of the Einstein-Rosen bridge outside of the event horizon and allowing a clear passage from one end to the other at less than the speed of light. "An advanced enough civilisation should be able to manipulate quantum matters in a good way to form a wormhole in principle," says Gao, but these traversable wormholes still have problems. They do little, for example to address the fundamental problem that naturally formed black holes don't necessarily link up with each other to form wormholes in the first place.

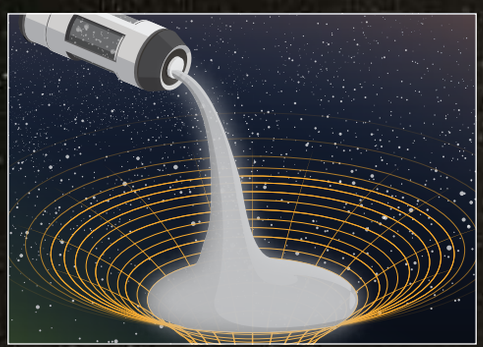
However Gao, along with his collaborators Daniel Jafferis at Harvard and Aron Wall at Stanford University, has recently outlined a new possibility – a type of wormhole whose ends are naturally linked together and which does not require exotic matter to keep it open. Their new calculations are based on a new conjecture in physics known as 'ER=EPR', which suggests that pairs of particles displaying a property called quantum entanglement are in fact linked together by micro-scale wormholes that naturally permeate the universe. Entanglement is a concept from quantum physics, usually applied to subatomic particles whose properties are 'fuzzy' but inextricably linked; for example it's possible to create a pair of entangled electrons whose spins are necessarily in the opposite directions, even if their exact orientations remain unknown. The details of ER=EPR are complex, but they suggest that non-traversable wormholes arise naturally between pairs of 'entangled' black holes.

If this is correct, explains Gao, such a wormhole could be made traversable by performing a 'quantum operation' on a pair of black holes – essentially putting them into a paired state of uncertainty and then letting them interact directly with each other in a quantum manner. If the ER=EPR model of cosmology is correct, says Gao, "the operation will inject some 'equivalent' negative energies to the black hole system, modifying the geometry of the Einstein-Rosen bridge to be traversable". But there's a catch: "Compared with the path outside of two black holes, the wormhole path behind the horizon is always longer. Unfortunately, no FTL travel can be made via this type of wormhole," Gao explains.

For the moment it seems the idea of using wormholes to travel to distant stars and galaxies remains off limits. However, it would be foolish to rule out the possibility of further breakthroughs in the future. And in the meantime, there's another intriguing possibility for FTL travel...

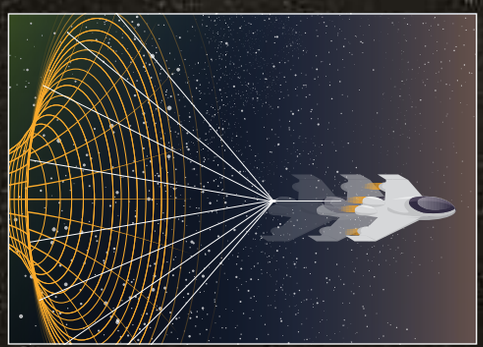
In contrast to wormholes, the so-called 'warp drive' cheats the speed limit more directly by creating a 'bubble' of warped space-time around a spacecraft. Inside the vehicle itself the local speed of light is never exceeded, but the laws of special

> "An advanced enough civilisation should be able to manipulate quantum matters to form a wormhole in principle" **Ping Gao**



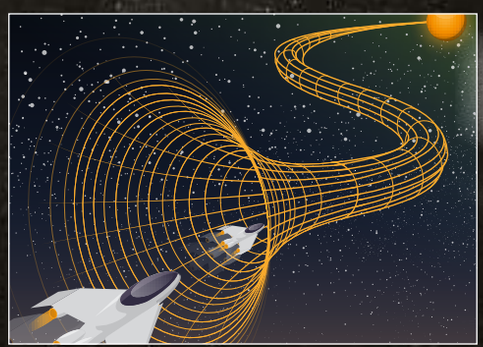
3. Make it traversable

Adding negative energy would create an anti-gravitational force. In the case of a non-traversable black hole wormhole this would draw the opening out into accessible space beyond the event horizon, while for a microscopic wormhole it could expand the tunnel to a traversable size.



4. First trip

The first exploration of a newly opened wormhole would be done by a manned spaceprobe. If it led somewhere safe and useful, the nearby end could be relocated closer to hand by a 'space tug', using the attractive force of gravity or repulsive 'antigravity' from the negative energy source.

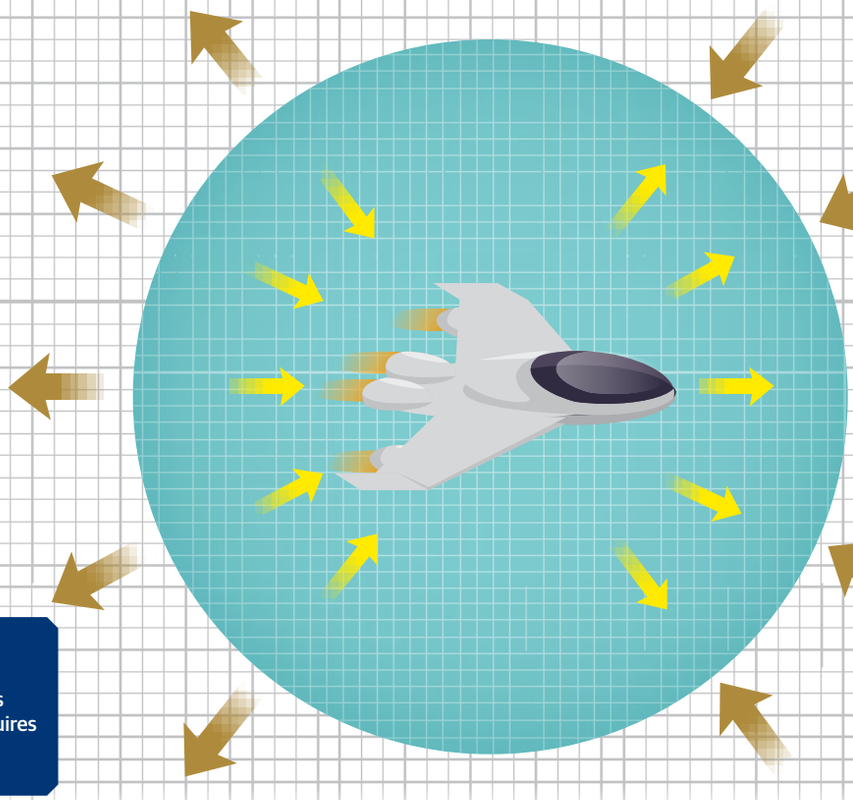


5. Cosmic motorways

Once a civilisation has learned how to open up one wormhole, it's easy to build a network of cosmic shortcuts. Some suggest they could even be used to build time machines, although the laws of physics mean that such a machine could not allow travel back to a time before it was created.

How a warp drive will work

The principle behind a warp drive sounds simple enough: to create a moving wave through space, pushed forward at faster-than-light speeds by a force that first contracts space ahead, and then causes it to expand. The spacecraft generating the warp drive, meanwhile, sits in a relatively flat region of space on the crest of the wave. Getting the idea to work in practice, however, requires revolutionary science and huge amounts of energy.



Speed control
The strength of the contraction and expansion governs the speed of the wave, but it's impossible to control this from inside the warp bubble.

Expanding space at back of wave
Getting space to push the wave requires negative energy to create an expanding region of space, and producing this is much harder.

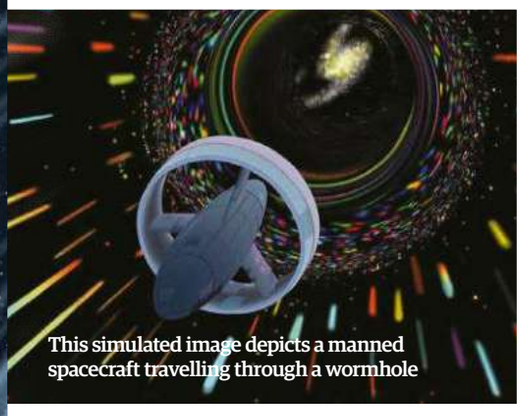
Riding the wave
The spacecraft itself sits in the middle of a bubble or ring of flat space, moving at a speed far less than the speed of light compared to its immediate surroundings.

Contracting space at front of wave
Causing space to contract is relatively easy, but still requires large amounts of mass and normal (positive) energy.

relativity bend enough to allow the bubble itself to move across vast gulfs of space at faster-than-light speeds, carrying the spacecraft with it.

Although the warp drive concept has been widely used in science fiction since the 1960s it was only in 1994 that Mexican physicist Miguel Alcubierre proposed a potential way for it to work in reality. Alcubierre showed how the flexibility of space in general relativity could allow the creation of a wave in which space contracted ahead of a moving spacecraft and expanded behind it. The spacecraft would sit inside a bubble of normal 'flat' space at the centre of the wave, and the wave itself would ripple across the universe effectively at a faster-than-light speed.

As with a wormhole, however, creating a working warp drive presents enormous technical challenges.



This simulated image depicts a manned spacecraft travelling through a wormhole

"In quantum physics, unlike in classical physics, negative energy on a microscopic scale is easy to find" **Ping Gao**

Once again exotic matter is required to generate the wave structure, and while physicists can imagine ways in which this might be achieved by a highly advanced civilisation, most of them would still require enormous amounts of energy, equivalent to the mass of a giant planet such as Jupiter.

In 2011, however, Harold G. "Sonny" White, an engineer in the Advanced Propulsion Physics Laboratory at NASA's Johnson Space Center, described a modified warp drive that replaced the bubble of flat space at the centre with a ring. This new version of the warp drive has far lower energy requirements – just a few tens of kilograms of mass-energy. Although still a vast amount of energy in today's terms, it could sustain a wave large enough to carry a crewed spaceship.

There are catches, of course. It seems there always are with potential FTL travel. In this case, the issues include the impossibility of steering the warp drive from the spaceship trapped within – since any signals attempting to manipulate the wave would need to travel faster than light in local space – and the possibly damaging effects of interstellar matter 'piling up' at the front of the wave. However, these, and the still-vast amounts of energy required, seem potentially less challenging than the questions that still surround wormholes.

Amazingly, experiments are already underway to test the warp-drive principle in the laboratory. White and his colleague Richard Juday have outlined a device called a 'warp-field interferometer' which could, in theory, detect tiny changes in the geometry of space created by possible warp-generating devices. The interferometer works by splitting a beam of laser light in two and sending its photons along two perpendicular paths before recombining them and studying the resulting interference patterns. The idea is that if one of the beams passes through a region of warped space the distance it travels will be changed, and this will show up in the interference.

Early attempts to warp space using an intense electric field proved inconclusive, but tests using lasers fired through a cylindrical microwave cavity, which traps high-energy radio waves, have proved more promising. White himself describes the interferometer as a 'humble experiment', but if a practical way of warping space can be found, then it might be the first step on a path that would revolutionise our exploration of the universe.

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			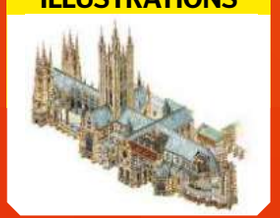	

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STARGAZER

GUIDES AND ADVICE TO GET STARTED IN AMATEUR ASTRONOMY

In this issue...

What's in the sky?


©TimothyBoocock

17 AUG
Venus is at greatest elongation east and is well placed for observation, shining at magnitude -4.3

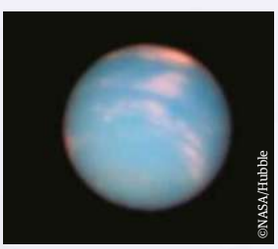
21 AUG
The alpha-Cygnids reach their peak of five meteors per hour

21 AUG
The Moon and Saturn make a close approach, passing within 2°07' of each other in Sagittarius

26 AUG
Venus is at greatest elongation west, well placed in the dawn sky, shining at magnitude -0.2


©MikeLewinski

7 SEP
Neptune reaches opposition, making it well placed for observation in Aquarius


©NASA/Hubble

9 SEP
The Piscids reach their peak of ten meteors per hour

Red light friendly
In order to preserve your night vision, you should read our observing guide under red light

Jargon buster

Conjunction
A conjunction is an alignment of objects at the same celestial longitude. The conjunction of the Moon and the planets is determined with reference to the Sun. A planet is in conjunction with the Sun when it and Earth are aligned on opposite sides of the Sun.

Right Ascension (RA)
Right Ascension is to the sky what longitude is to the surface of the Earth, corresponding to east and west directions. It is measured in hours, minutes and seconds since, as the Earth rotates on its axis, we see different parts of the sky throughout the night.

Declination (Dec)
This tells you how high an object will rise in the sky. Like Earth's latitude, Dec measures north and south. It's measured in degrees, arcminutes and arcseconds. There are 60 arcseconds in an arcminute and there are 60 arcminutes in a degree.

Magnitude
An object's magnitude tells you how bright it appears from Earth. In astronomy, magnitudes are represented on a numbered scale. The lower the number, the brighter the object. So, a magnitude of -1 is brighter than an object with a magnitude of +2.

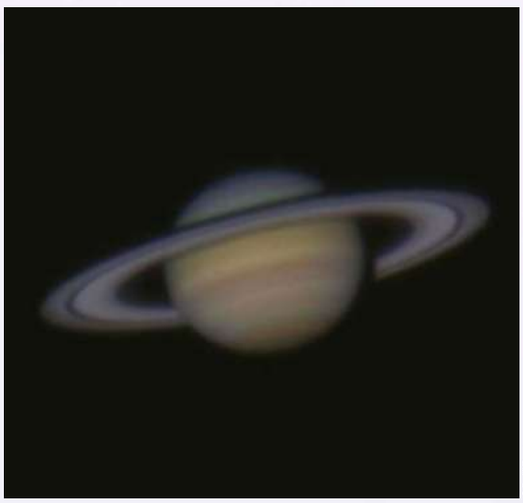
Opposition
When a celestial body is in line with the Earth and Sun. During opposition, an object is visible for the whole night, rising at sunset and setting at sunrise. At this point in its orbit, the celestial object is closest to Earth, making it appear bigger and brighter.

Greatest elongation
When the inner planets, Mercury and Venus, are at their maximum distance from the Sun. During greatest elongation, the inner planets can be observed as evening stars at greatest eastern elongations and as morning stars during western elongations.

17 AUG
Conjunction between the Moon and Jupiter in Libra

17 AUG
The Moon and Jupiter make a close approach, passing within 4°17' of each other in Libra

21 AUG
Conjunction between the Moon and Saturn in Sagittarius



28 AUG
Mercury is at dichotomy, where it will reach half phase in the dawn sky, shining brightly at magnitude -0.5

11 SEP
Comet 21P/Giacobini-Zinner will make its closest approach to the Sun, shining at magnitude 6.5 in Auriga

- Naked eye
- Binoculars
- Small telescope
- Medium telescope
- Large telescope

STARGAZER

Planetarium

30 August 2018

Moon calendar

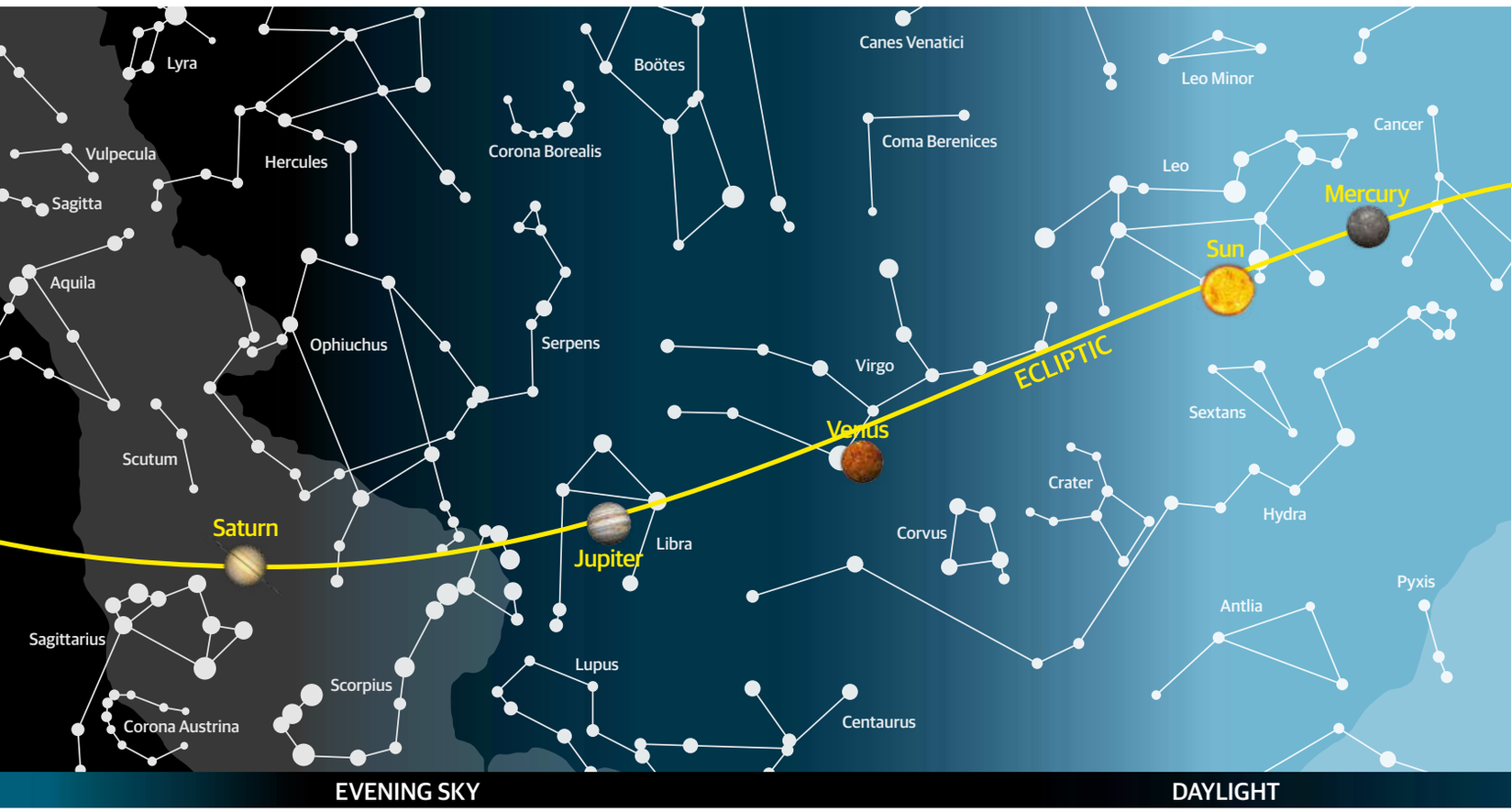
* The Moon does not pass meridian on 25 August

16 AUG 33.5% 12:00 22:59	**17 AUG** 44.0% 13:12 23:25	**18 AUG** FQ 54.5% 14:21 23:53	**19 AUG** 64.5% 15:26 --:--			
20 AUG 73.7% 00:26 16:26	**21 AUG** 81.8% 01:04 17:20	**22 AUG** 88.7% 01:48 18:08	**23 AUG** 94.1% 02:39 18:49	**24 AUG** 97.8% 03:36 19:24	**25 AUG** *--.-% 04:37 19:53	**26 AUG** FM 99.7% 05:41 20:19
27 AUG 99.7% 06:46 20:41	**28 AUG** 97.6% 07:53 21:03	**29 AUG** 93.6% 09:01 21:23	**30 AUG** 87.6% 10:10 21:45	**31 AUG** 79.8% 11:20 22:09	**1 SEP** 70.5% 12:32 22:36	**2 SEP** 59.9% 13:44 23:09
3 SEP LQ 48.6% 14:56 23:49	**4 SEP** 37.0% 16:04 --:--	**5 SEP** 25.8% 00:41 17:05	**6 SEP** 15.8% 01:43 17:57	**7 SEP** 7.8% 02:56 18:40	**8 SEP** 2.5% 04:16 19:15	**9 SEP** NM 0.2% 05:38 19:45
10 SEP 1.0% 07:00 20:11	**11 SEP** 4.7% 08:20 20:35	**12 SEP** 10.8% 09:38 20:59	**13 SEP** 18.8% 10:53 21:24			

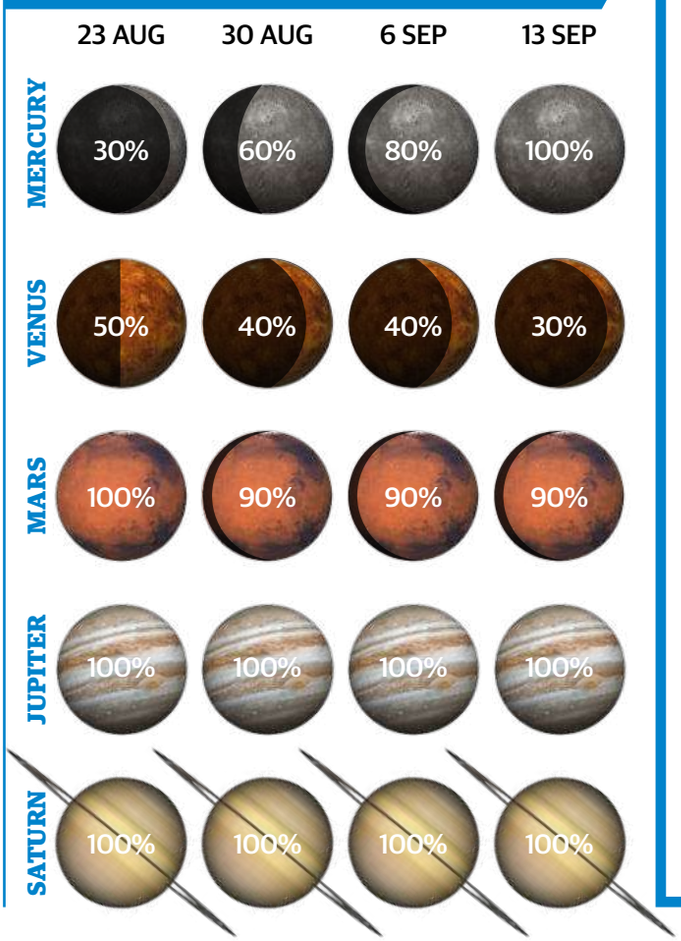
% Illumination
Moonrise time
Moonset time

FM Full Moon
NM New Moon
FQ First quarter
LQ Last quarter

All figures are given for 00h at midnight (local times for London, UK)



Illumination percentage



Planet positions

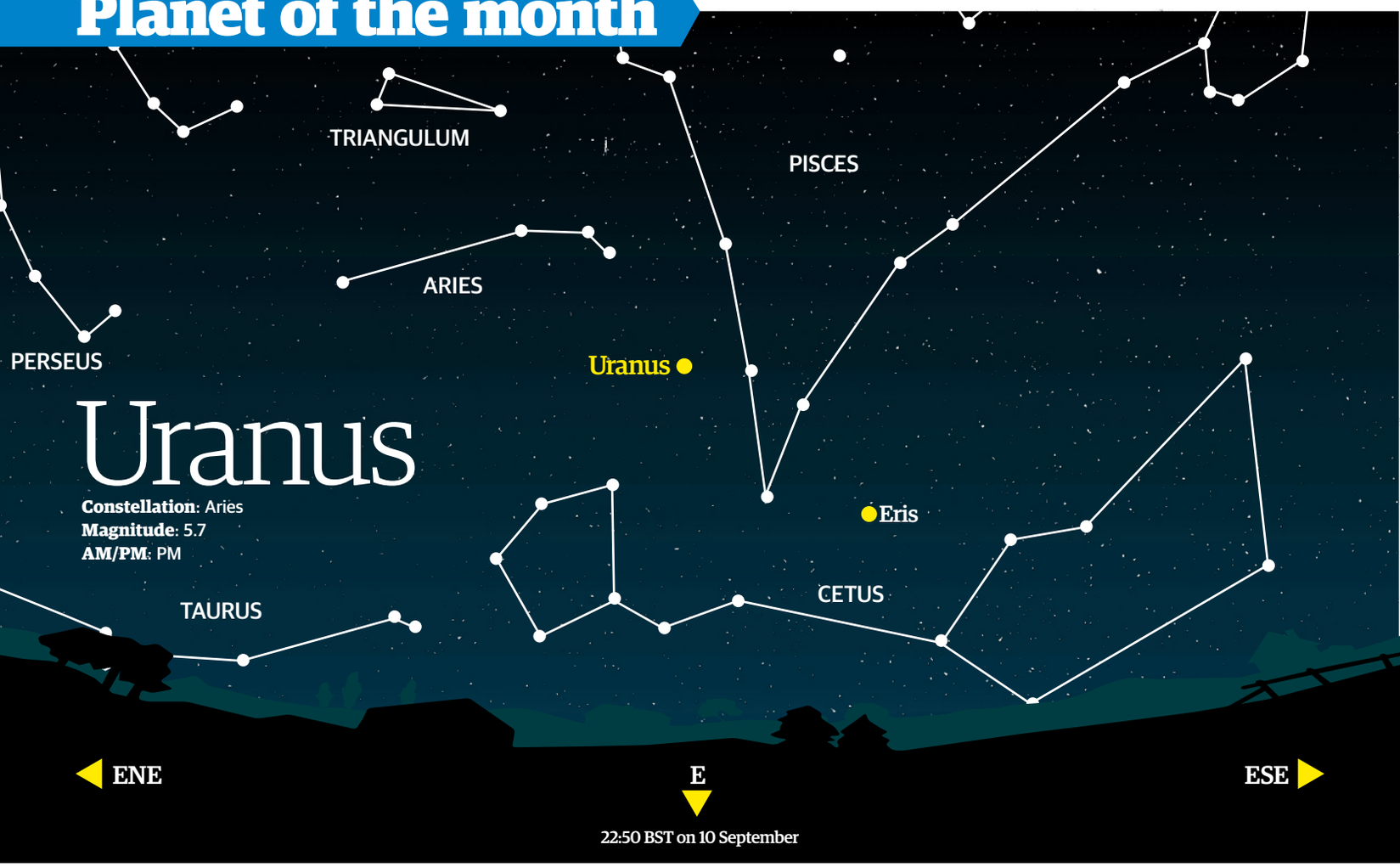
All rise and set times are given in BST

	Date	RA	Dec	Constellation	Mag	Rise	Set
MERCURY	16 Aug	08h 53m 13s	+13° 48′09″	Cancer	2.8	04:58	19:30
	23 Aug	08h 59m 19s	+15° 38′ 29″	Cancer	0.5	04:24	19:17
	30 Aug	09h 24m 17s	+15° 32′ 45″	Leo	-0.6	04:24	19:16
	06 Sep	10h 08m 44s	+12° 59′ 02″	Leo	-1.1	04:55	19:18
	13 Sep	10h 58m 45s	+08° 29′ 13″	Leo	-1.4	05:42	19:16
VENUS	16 Aug	12h 29m 59s	-04° 43′ 13″	Virgo	-4.3	10:01	21:30
	23 Aug	12h 53m 16s	-08° 01′ 09″	Virgo	-4.4	10:23	21:09
	30 Aug	13h 15m 11s	-11° 09′ 15″	Virgo	-4.4	10:34	20:47
	06 Sep	13h 35m 25s	-14° 03′ 42″	Virgo	-4.5	10:42	20:23
	13 Sep	13h 53m 20s	-16° 40′ 00″	Virgo	-4.5	10:48	19:59
MARS	16 Aug	20h 11m 31s	-26° 33′ 14″	Capricornus	-2.5	20:01	03:04
	23 Aug	20h 07m 58s	-26° 27′ 04″	Capricornus	-2.3	19:29	02:34
	30 Aug	20h 07m 12s	-26° 07′ 58″	Sagittarius	-2.2	18:58	02:08
	06 Sep	20h 09m 14s	-25° 37′ 41″	Capricornus	-2.0	18:29	01:46
	13 Sep	20h 13m 56s	-24° 57′ 39″	Capricornus	-1.8	18:01	01:28
JUPITER	16 Aug	14h 51m 14s	-15° 27′ 51″	Libra	-2.0	13:28	22:54
	23 Aug	14h 54m 15s	-15° 42′ 43″	Libra	-2.0	13:05	22:28
	30 Aug	14h 57m 43s	-15° 59′ 13″	Libra	-2.0	12:43	22:02
	06 Sep	15h 01m 36s	-16° 17′ 08″	Libra	-1.9	12:21	21:37
	13 Sep	15h 05m 53s	-16° 36′ 12″	Libra	-1.9	12:00	21:12
SATURN	16 Aug	18h 11m 29s	-22° 39′ 17″	Sagittarius	0.3	17:33	01:33
	23 Aug	18h 10m 37s	-22° 40′ 31″	Sagittarius	0.3	17:05	01:04
	30 Aug	18h 10m 06s	-22° 41′ 40″	Sagittarius	0.4	16:37	00:36
	06 Sep	18h 09m 54s	-22° 42′ 45″	Sagittarius	0.4	16:09	00:08
	13 Sep	18h 10m 03s	-22° 43′ 44″	Sagittarius	0.4	15:42	23:37

This month's planets

While the Red Planet slowly fades after coming to opposition, challenge yourself to look upon the green-tinged, distant Uranus

Planet of the month



Many amateur astronomers and sky-watchers have never even bothered to look for Uranus because it has a reputation for being too faint, too boring and too bland to look for when there are so many bright, exciting and colourful things to look at.

Indeed, it is so unremarkable visually that it was seen in the night sky, recorded and mistaken for a star by several notable observers before it was eventually recognised as a planet by William Herschel in 1781.

After its discovery Uranus was observed regularly by professional astronomers, and their calculations showed it lies almost 20-times further from the Sun than the Earth and orbits the Sun once every 84 years. But no matter how big a telescope they used they only ever saw Uranus as a small, featureless, blue-green disc. It took the Voyager 2 probe, speeding past Uranus in 1986, just days before the Challenger space shuttle tragedy, to turn that bland disc into a real world.

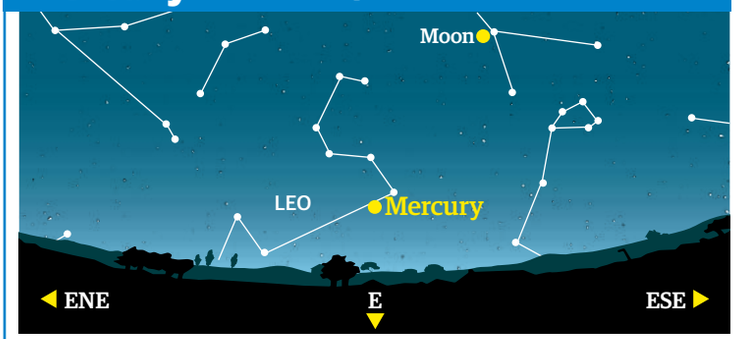
We now know that Uranus is an ice giant world, four-times wider than Earth, with a system of nine dark rings and a family of 27 moons, some of them as fascinating as the more famous satellites of Jupiter and Saturn. Although the planet's atmosphere appears blank and featureless as seen from Earth, just as it did to the Voyager probe's cameras, we now know that it does have structures, cloud bands and storms shaped by the planet's ferocious, 900 kilometres (559 miles) per hour winds.

It's no real surprise that Uranus hid in the sky undiscovered for so long: shining at just beneath sixth magnitude it is, technically, a naked-eye object, but to see it without optical assistance of some kind you would have to have very good eyesight, be standing beneath a pitch-black sky with no light pollution or moonlight to spoil the view and know exactly which one of the many, many faint stars 'up there' it is.

This month Uranus is an evening object, lurking among the unremarkable stars of the unremarkable constellation of Aries. At the start of our observing period it rises around 10:30pm and is visible through the night until the sky begins to brighten with the approach of dawn. By the middle of September Uranus is rising before 9pm, so will be visible earlier and for longer.

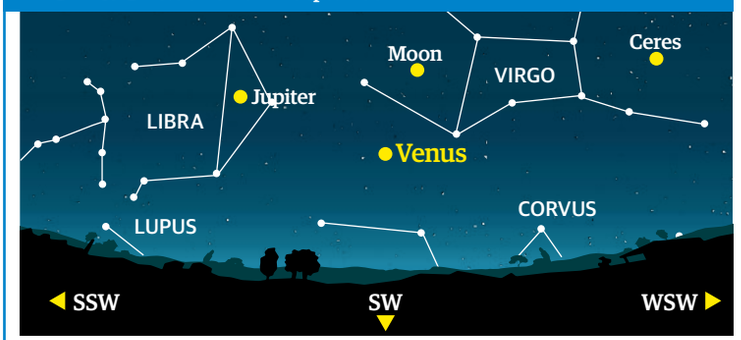
Although your chances of seeing it with your naked eye are slim for the aforementioned reasons, binoculars will make it stand out from the crowd of stars around it by enhancing its green-blue colour.

Mercury 05:50 BST on 5 September



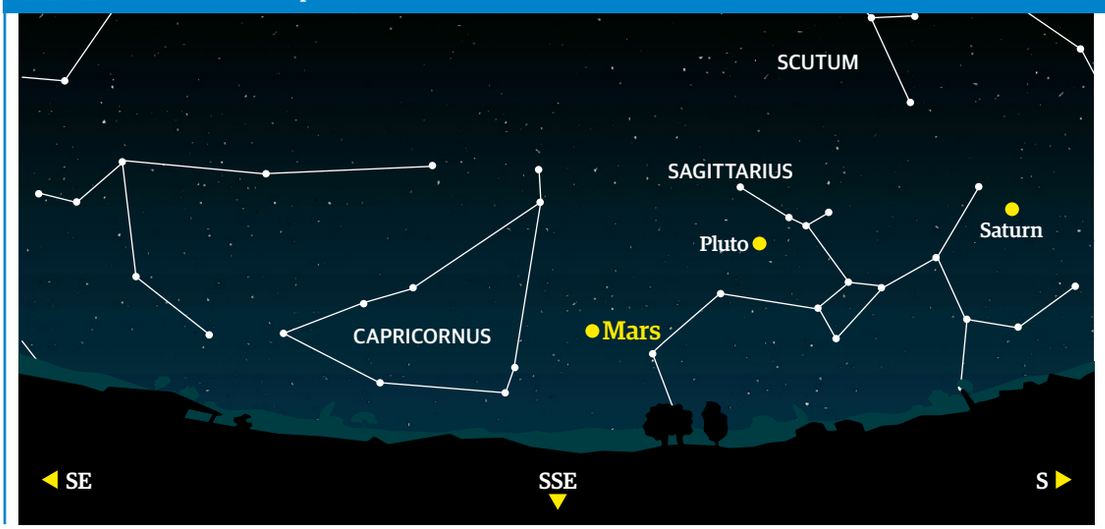
Constellation: Cancer into Leo
Magnitude: -1
AM/PM: AM
At the start of our observing period this tiny, rocky world lies in Cancer and is a faint naked-eye object. Every morning sees it rising a little earlier, shining a little brighter and becoming easier to see. It will be at its best before dawn on 27 August, when it will rise an hour-and-a-half before the Sun.

Venus 18:00 BST on 12 September



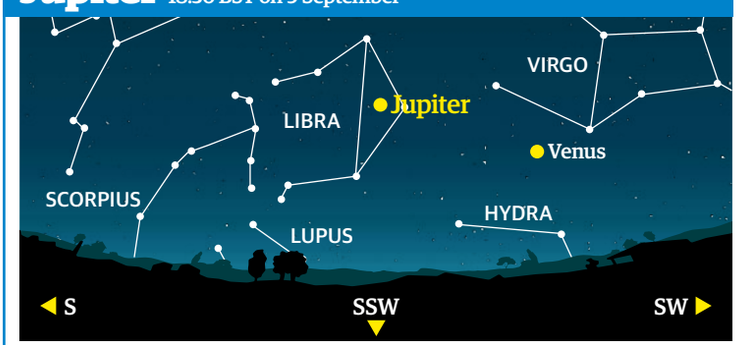
Constellation: Virgo
Magnitude: -4.3
AM/PM: PM
Despite the bright twilight sky the planet should be visible to the naked eye, shining brightly above the horizon. Venus will have plenty of company this month, too. You will see Jupiter shining over to its left, and a beautiful crescent Moon close to it on the evening of 16 August, and again after sunset on 12 September.

Mars 20:00 BST on 10 September



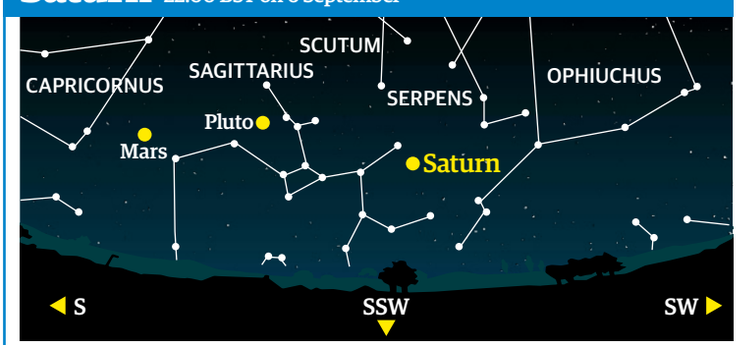
Constellation: Capricornus
Magnitude: -2.5
AM/PM: PM
If you saw Mars when it was blazing at opposition late last month, you'll notice quite a difference. Having passed opposition, Mars is now fading as the distance between it and Earth increases. It will remain low in the sky during this month, and that lack of altitude will reduce its apparent brightness. However, the Red Planet will still be a bright naked-eye object, immediately visible to the naked eye in the south as twilight deepens, and it will still be a striking sight in binoculars and telescopes. Look for the almost full Moon shining just above Mars after dark on 23 August.

Jupiter 18:30 BST on 9 September



Constellation: Libra
Magnitude: -2
AM/PM: PM
The giant gas planet will become visible low in the southwest half an hour or so after sunset, looking like a bright star shining in the twilight. However, it won't be visible for long – it will set by around 10pm. Look out for the crescent Moon shining less than five degrees away from Jupiter on the evening of 17 August.

Saturn 22:00 BST on 6 September



Constellation: Sagittarius
Magnitude: 0.3
AM/PM: PM
Saturn will be a yellow-white star low in the south as darkness falls, to the right of Mars and just above the famous 'Teapot' asterism in Sagittarius. Look for a waxing gibbous Moon shining to Saturn's upper right on the evening of 20 August, and to its upper left the following evening.

Top tip!

Look for Harpalus when it is close to the 'terminator', the line between lunar night and day. It will stand out much more clearly here.

Moon tour

Harpalus crater

Our destination this month is the star of one of the most famous sci-fi films ever made...

This crater was the uncredited star of a film that was released 18 years before *2001: A Space Odyssey* and stunned audiences with its realistic depiction of space exploration – *Destination Moon*.

Of course, many lunar features and landmarks have been featured in science-fiction films and TV shows over the years. Some of the very first science-fiction films were silent movies that showed people visiting the Moon in glorified artillery shells fired from huge cannons, to meet either bizarre-looking aliens or dancing girls.

In the aforementioned classic *2001*, astronauts excavated an enigmatic alien monolith from deep beneath the crater Clavius. In *Star Trek: First Contact* the USS Enterprise's time-travelling First Officer Riker waxes lyrical to warp drive inventor Zefram Cochrane about gazing up at the terraformed Moon in his century and seeing the lights of cities shining there, and Lake Armstrong too. The Moon has even been visited by Spongebob Squarepants!

But in 1950 the film *Destination Moon* was the first to attempt to show the Moon, and the view from it, realistically, by featuring the stunning artwork and models of artist Chesley Bonestell. Many consider Bonestell to be the original – and still the best – 'space artist'. Although his lunar landscapes were much more dramatic and jagged than the ones the Apollo astronauts would gaze out on and explore decades later, they were still far more realistic than anything painted or shown on screen before.

When *Destination Moon* came out, 19 years before Apollo landed on the Moon for real, it took audiences on a thrilling mission to a real crater you can find for yourself on the Moon this month: Harpalus.

Sitting almost in the centre of Mare Frigoris or 'The Sea of Cold', a long, narrow stain just above the beautiful crescent-shaped Sinus Iridum in the far northerly reaches of the Moon, Harpalus is a physically small crater. Just 40 kilometres (25 miles) across and 3 kilometres (1.8 miles) deep, it is less than a third as wide as Copernicus and just one eighth the size of Clavius. Visually it is an unremarkable feature, not helped by the fact that its close proximity to the lunar north pole means that our view of it from here on Earth is greatly foreshortened, so it usually looks like more of an oval than a circular feature. However, sometimes the Moon's libration – the axial wobble it has which causes it to occasionally but regularly tilt features around its limb towards us and then away from us again, meaning we can sometimes see a little way 'around the edge' of the Moon – sometimes causes Harpalus to be tipped towards us, allowing us a much better view. This month Harpalus will be well placed for observation.

Photos taken from directly above by orbiting probes show Harpalus is roughly circular, with shallow, terraced walls, a trio of low mountains rising up from its hummocky floor and a system of rays spreading away from it. In this way it looks rather like a smaller version of the 'celebrity' crater Copernicus. If you look at Harpalus through a small telescope around 30 and 31 August, when it is at its best, you will be able to see right into it and will be able to make out details on its walls and floor, including a small crater there.

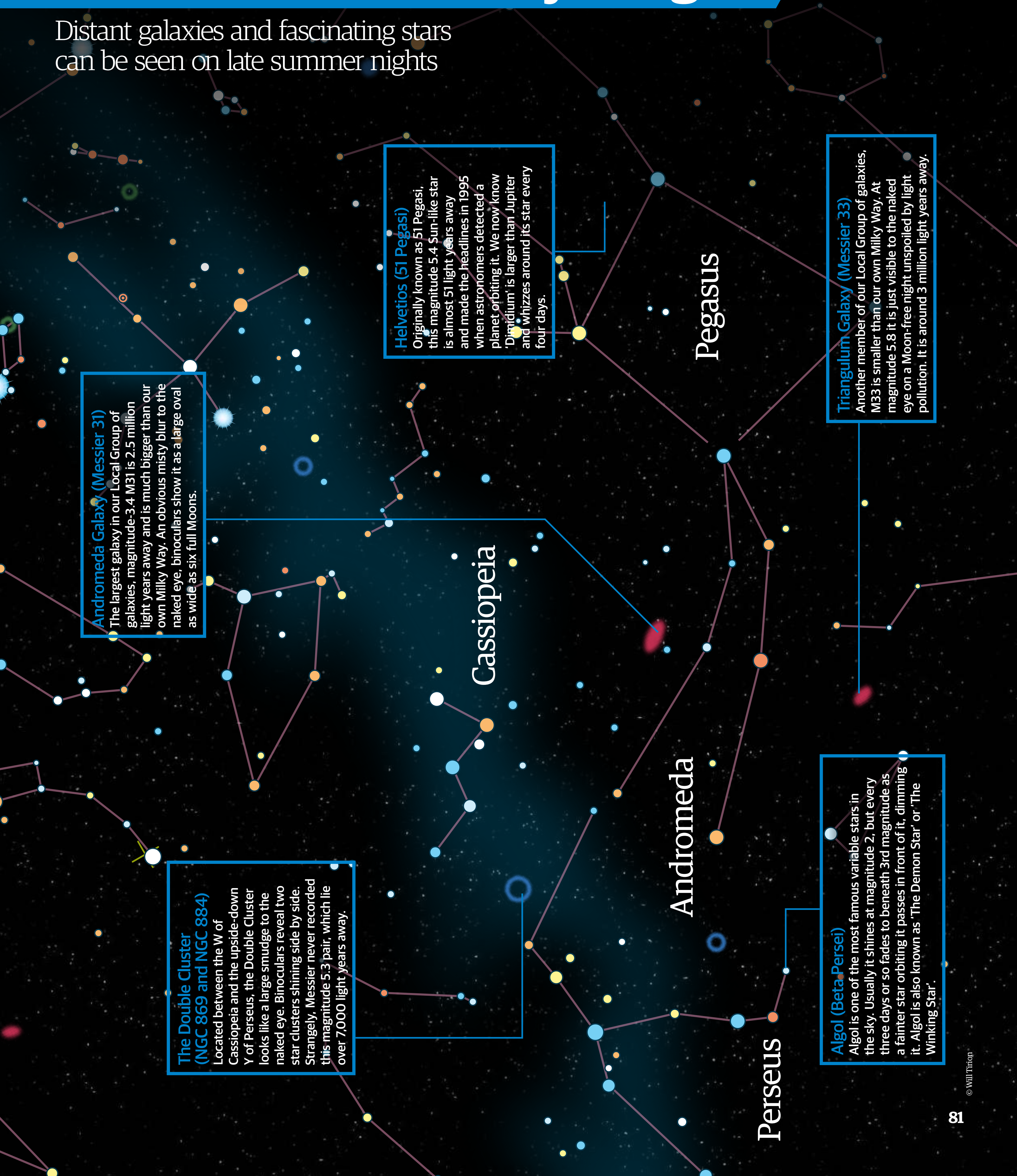
So when can you see this crater at its best this month?

At the start of this issue's observing period Harpalus cannot be seen; it is fully hidden in shadow. You'll have to wait until the evening of 22 August to see it emerging from the darkness, as the terminator passes over it and allows the Sun to shine on its raised rim again.

By the evening of 23 August the crater will be in full sunlight and very easy to see in a small telescope. It should even be visible – just – through a good pair of binoculars. The crater will remain fully illuminated until 4 September, when the terminator will return and begin to sweep back over it again, cutting off the sunlight. By the evening of 5 September Harpalus will be out of our view once more.

This month's naked eye targets

Distant galaxies and fascinating stars can be seen on late summer nights



Helvetios (51 Pegasi)

Originally known as 51 Pegasi, this magnitude 5.4 Sun-like star is almost 51 light years away and made the headlines in 1995 when astronomers detected a planet orbiting it. We now know 'Dimidium' is larger than Jupiter and whizzes around its star every four days.

Triangulum Galaxy (Messier 33)

Another member of our Local Group of galaxies, M33 is smaller than our own Milky Way. At magnitude 5.8 it is just visible to the naked eye on a Moon-free night unspoiled by light pollution. It is around 3 million light years away.

Andromeda Galaxy (Messier 31)

The largest galaxy in our Local Group of galaxies, magnitude-3.4 M31 is 2.5 million light years away and is much bigger than our own Milky Way. An obvious misty blur to the naked eye, binoculars show it as a large oval as wide as six full Moons.

The Double Cluster (NGC 869 and NGC 884)

Located between the W of Cassiopeia and the upside-down Y of Perseus, the Double Cluster looks like a large smudge to the naked eye. Binoculars reveal two star clusters shining side by side. Strangely, Messier never recorded this magnitude 5.3 pair, which lie over 7,000 light years away.

Algol (Beta Persei)

Algol is one of the most famous variable stars in the sky. Usually it shines at magnitude 2, but every three days or so fades to beneath 3rd magnitude as a fainter star orbiting it passes in front of it, dimming it. Algol is also known as 'The Demon Star' or 'The Winking Star'.

How to...

Catch noctilucent clouds

During long summer nights the sky can be too bright to observe some of the fainter deep-sky targets, so why not see if you can spot this stunning ghostly phenomena?

You'll need:

- ✔ Access to social media
- ✔ An observing site with no trees or buildings on the northern horizon
- ✔ A pair of binoculars
- ✔ A phone or camera on a tripod
- ✔ Warm clothes
- ✔ Hot drink in a flask and some snacks

During the summer months the night sky doesn't get dark enough to see faint stars and deep-sky objects, so many stargazers go into hibernation. Others find alternative celestial attractions to observe such as noctilucent clouds (NLC), which are clouds of ice crystals and dust that form in the upper atmosphere.

Being so high means NLCs are illuminated by the Sun's rays at night, long after sunset. NLCs can be distinguished from other clouds because they shine behind them, silhouetting them like ink blotches.

You don't need fancy equipment to see NLCs; they're visible to the naked eye. However, a pair of binoculars is great because NLCs often have very fine, intricate structures – wisps, curls, streamers and billows – that can't be seen well. NLC are very photogenic too, but you really need a digital SLR to take good images.

NLCs are only visible for northern hemisphere observers between the end of May and the end of July. After 11:30pm on any clear night during this NLC season you should check the northern sky for signs of NLCs – typically faint wisps of blue, like silvery vapour trails. They might either fade away or develop into something more impressive – there's no way of telling in advance what they will do.

Most NLC displays are modest affairs, restricted to a few bands or patches of glowing cloud hovering almost reluctantly above the northern horizon. But if you're lucky enough to catch a major display of NLCs you will be blown away; there is nothing else like it in astronomy.

During a major display NLCs can form beautiful shapes – ghostly streamers, curls and tendrils of silvery-blue light. Many NLCs show a distinctive cross-hatch pattern, and binoculars will show you the insides and edges of the clouds changing shape almost by the second, sculpted by the silent winds blowing high above the Earth.

Watching NLCs requires a lot of patience. If a major display occurs you can easily be out from midnight through until dawn, so dress warmly and take snacks and a hot drink. You'll need to look for them from somewhere with a low, flat northern horizon without any trees, buildings or hills to block your view. If you can see the star Capella, your observing site should be fine.

Tips & tricks

Start looking around 11:30pm

There's no point going out hunting too early, as they don't usually appear until around midnight or later.

Use Capella as your guide

Make sure you're facing in the right direction. NLC typically appear to the left or right of Capella, Auriga's brightest star.

Be patient!

NLC displays are usually very slow to develop, so if you see nothing straight away, wait.

Don't give up too soon!

If a display dies down don't assume it's over and go home. It might brighten again! Many displays fade away part way through before coming back.

Look for NLC before dawn

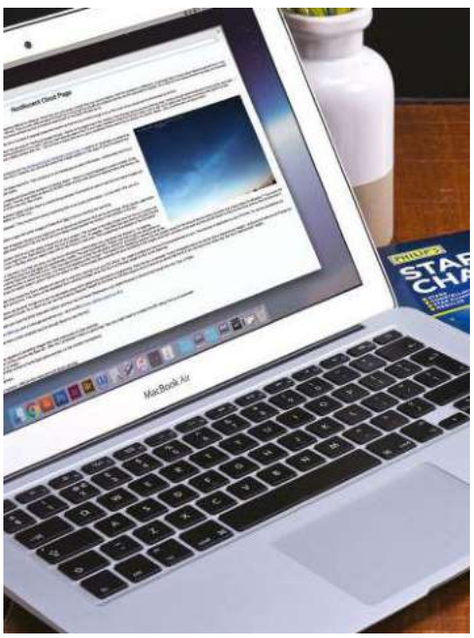
Some NLC displays don't really turn on until before sunrise, so it's worth keeping an eye on the sky.

Being in the right place at the right time

Use social media to your advantage to have a better chance of viewing NLCs

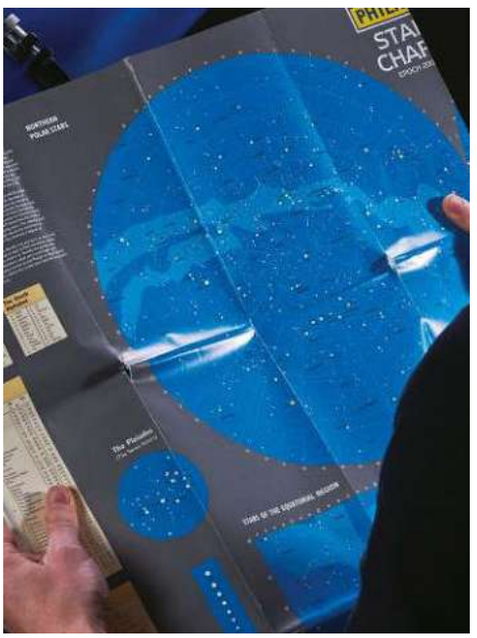
NLCs can't be predicted very accurately in advance, but you can improve your chances of seeing them by using social media; many observers post "NLC visible now!" alerts on Facebook and Twitter when a display occurs, so if you follow these then you'll know when to head out – and won't be sitting on the sofa unaware that the northern sky behind your house is shining with beautiful glowing clouds.

Send your photos to
space@spaceanswers.com



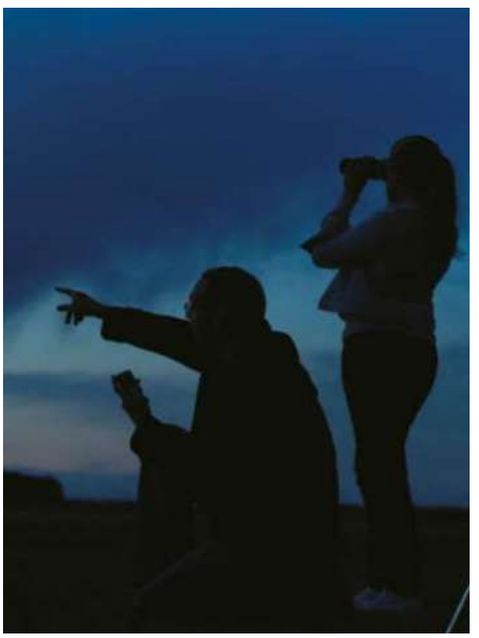
1 Check online for activity

Checking websites and social media platforms for alerts or reports of activity from NLC observers before heading out can save you wasting time and petrol.



2 Use targets as your reference

The bright yellow-white star Capella will show you where to start looking in the sky for NLC. Most NLC displays appear under or around this well-known star.



3 Know what to look for

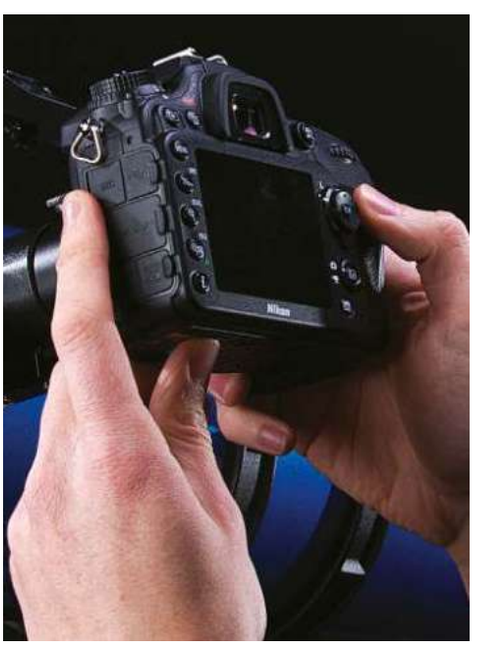
NLC can shine with different colours. Be on the lookout for simple arcs or wisps of gold or more complex swirls and whirls of electric blue, often silhouetting clouds lower in the atmosphere.

4 Be prepared for brightening and fading

If a display dies down don't give up – it might brighten. Many of the largest displays fade away part way through before coming back.

5 Upgrade to binoculars

Binoculars will show you beautiful detail inside NLC – whirls, whorls and swirls, cross-hatch patterns and long, sinuous lines of smoky cloud, shining shades of violet and electric blue.



6 Try taking photos

A digital SLR on a steady tripod can capture great images of NLC. Set a high ISO and take exposures of several seconds. If fine details are washed out use shorter exposures.

California Nebula (NGC 1499)

Deep sky challenge

Treasures of Perseus and Cassiopeia

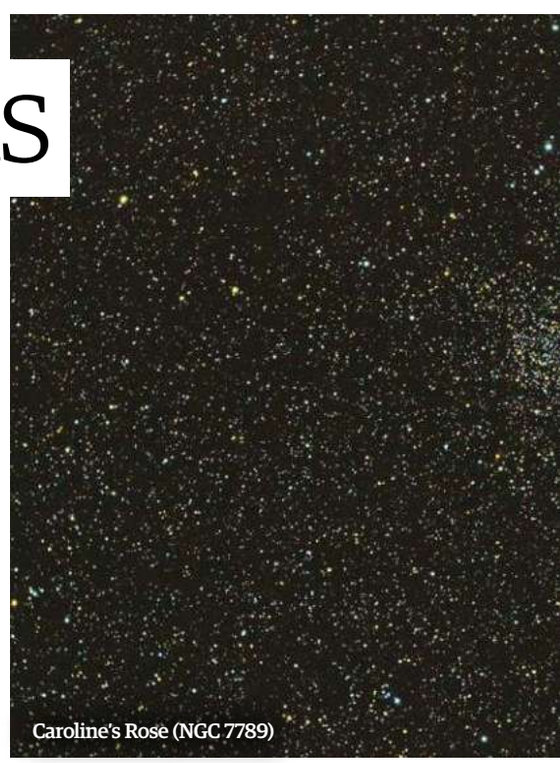
A ghostly nebula and a rose-shaped star cluster are among your observing challenges this month

You've had it too easy recently, so there are some real observing challenges this month, hidden among the bright, familiar stars of the much-loved constellations of Perseus and Cassiopeia. However, with the sky staying bright until the very small hours at this time of year you'll need to stay up late or get up early to see them.

NGC 7789 is a loose cluster popularly known as 'Caroline's Rose'. Discovered by Caroline Herschel in 1783, its many loops of stars and the dark gaps between them give it – some observers claim – a strong resemblance to a white rose. See what you think when you have it in the middle of your telescope's eyepiece.

Messier 76 in Perseus is a planetary nebula nicknamed the 'Little Dumbbell Nebula', and is infamous among deep-sky observers as one of the hardest to see of Messier's catalogue of 110 objects. Definitely one for the owners of large-aperture 'light buckets' to try and hunt down.

Owners of small telescopes aren't left out, though. The pretty little magnitude 5.6 cluster M34 is worth looking at through any telescope at any time.



Caroline's Rose (NGC 7789)

1 The California Nebula (NGC 1499)

NGC 1499 is quite large, but its very low surface brightness means it is hard to see in small telescopes, and is only seen properly through light-gulping medium- or large-aperture instruments.

2 NGC 559

This ninth-magnitude loose open cluster in Cassiopeia contains several dozen stars, and is best seen in medium aperture or larger telescopes. It is 3,700 light years away and approximately 4′ across.

3 Little Dumbbell Nebula (Messier 76)

Magnitude 10.1 M76 is one of the most difficult to find of all Messier's objects; only large instruments will show it clearly. Despite its nickname it looks more like a misty elongated patch than a twin-lobed dumbbell.

4 Messier 34

Just north of Algol, M34 is a very loose open cluster of 100 or so stars covering the same area as the full Moon. Small telescopes give the best view of the trio of arms coming from its centre.

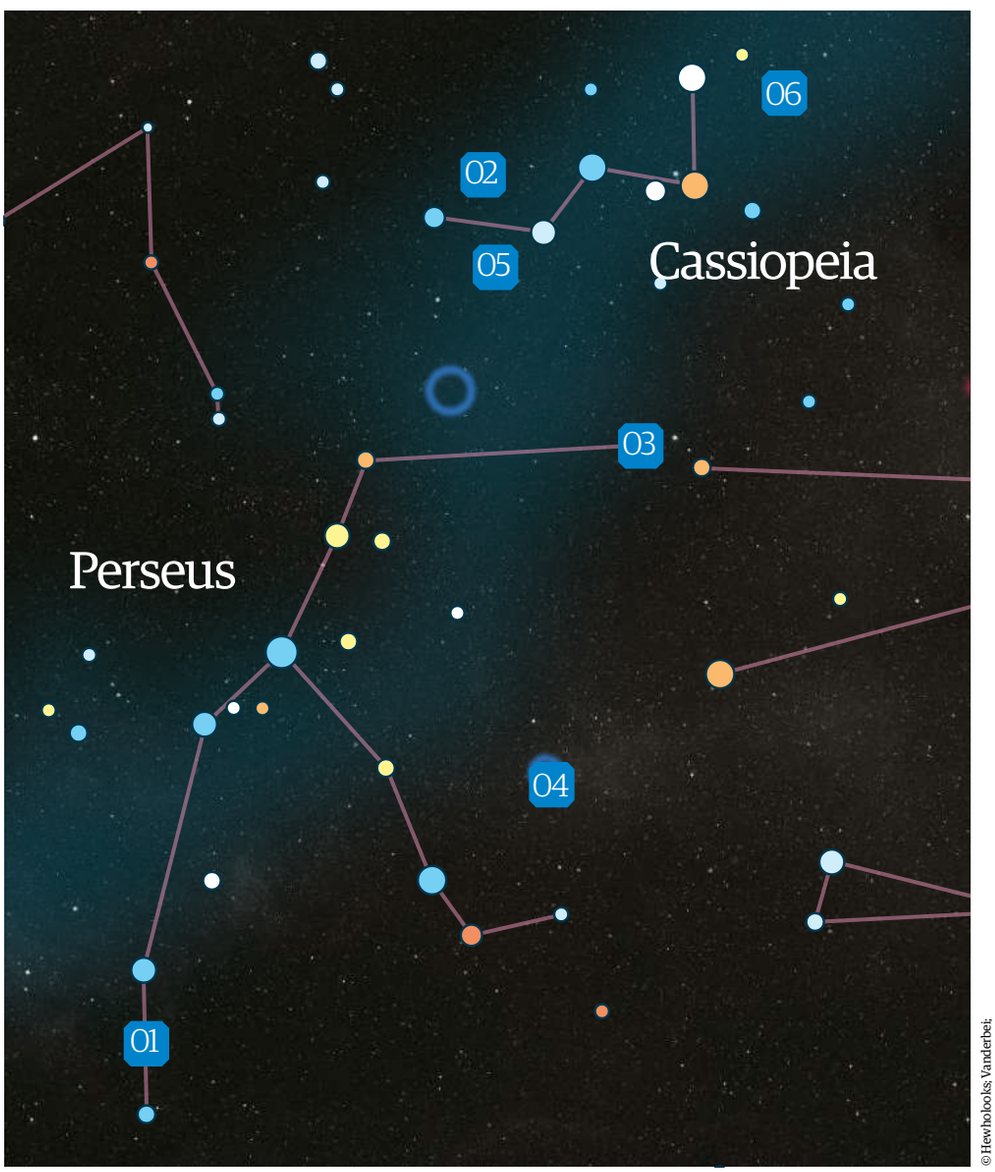
5 Messier 103

This 7.4-magnitude open cluster is one of the sky's 'hidden gems'. Small- and medium-aperture telescopes give lovely views of the mini Orion's Belt across its centre, an orange star with an icy blue star on either side.

6 Caroline's Rose (NGC 7789)

The stars in magnitude 6.7 NGC 7789 are so densely packed that some think it looks more like a globular cluster than a loose cluster. Either way, medium- and large-aperture telescopes are needed to see its stellar petals' subtle outlines.


Little Dumbbell Nebula (M76)



How to...

Observe the Perseid meteor shower

With no Moon to spoil the view, this year's show could be one of the best in years - make sure you're prepared enough to catch it

You'll need:

- ✔ Dark-sky observing site
- ✔ Warm clothing
- ✔ Reclining chair
- ✔ Drinks and snacks
- ✔ Binoculars
- ✔ Red torch, pen and notebook
- ✔ Observing partners (if possible)

Every mid-August sky-watchers flock to the countryside to watch shooting stars zip across the sky during the annual Perseid meteor shower. It's one of the most reliable meteor showers, and unlike in 2017 this year there will be no bright Moon to spoil things, so we should be in for a real treat. Here's how to make the most of this popular event.

This year's shower peaks on the night of 12 to 13 August, but you'll see more meteors than usual for a few nights either side of that date.

August nights can be mild, but you will get cold as the temperature drops so dress as if it's winter not summer. You should also take a flask of a hot drink with you to warm you up, and some snacking food for when your eyes start drooping and you need an energy boost.

Choosing a good observing site is absolutely vital. Find somewhere as far away from light pollution and traffic as possible. There should also be no trees, buildings or hills around it to obstruct your view of the sky either - you want to see as much of the sky as you can so no meteors drop out of your view.

Start watching from around 11:30pm and stay out as long as you can. Lie back comfortably in a reclining chair so you're not straining your neck. When you start to feel tired get up and have a walk around. Clap your hands together, have a drink from your flask and a bite to eat. You'll be refreshed afterwards and ready to watch more meteors.

Don't look straight at the constellation of Perseus. If you look off to the side, or even overhead, you'll see more meteors than you will looking directly at the 'radiant'.

You can watch the Perseids on your own but it can feel very lonely at 3:00am, and once you start to feel cold and tired you will be tempted to go home early. This is a mistake because most meteor showers peak in the small hours before dawn. If you go with friends it will be more fun and you can keep each other awake! Being more practical, by facing different directions you'll see more meteors as a group than one person would on their own.

It's fun to try and capture some meteors with a DSLR camera on a tripod, taking long exposures, but be prepared to fail totally: the chances of one flashing across the sky exactly where your camera is pointing are very slim!

Tips & tricks

Get away from it all

Find an observing site with as little light pollution as possible, and a view of as much of the sky as possible too.

Stay warm

August might be a summer month, but it still gets chilly late at night.

Be patient

Be prepared for lulls in the shower when you don't see any shooting stars for a while.

Try taking photos

...but don't worry if you don't capture any meteors. It's pure pot luck.

Two's company

Facing different directions you'll see more meteors than a single observer. You'll keep each other awake too!

Stay out as long as you can

Try to stay out all night – most meteors will appear in the hours before dawn.

Keeping a record

Take note of any very bright meteors you see streak across the sky

Bright meteors often leave behind wispy, glowing trails which can linger. Through binoculars you'll be able to see them twisting and changing shape before they fade. If you are lucky enough to see any very bright meteors quickly jot down the time you saw them, where they were in the sky, their colour and how bright they were; professionals who study meteors will find such information extremely useful.

Send your photos to
space@spaceanswers.com

1 Choose the right location

Find an observing site with no light pollution and no tall trees, hills or buildings around it. The more open sky, the more meteors you will see.

2 Dress up warm

You will be outside a long time, so dress warmly and take a flask of something hot to warm you up when it gets chilly.

3 Try taking long-exposure photos

You can try capturing meteors on long-exposure photos taken with a camera on a tripod, but don't be surprised if you don't catch any.

4 Make a note of the brighter meteors

If you see any very bright meteors try to record their details – direction, duration, colour and brightness. Meteor experts will find that very useful.

5 Be quick with your binoculars

Use your binoculars to zoom in on any glowing 'trails' left behind by the brightest meteors. They can be very colourful and last for several minutes.

6 Take a walk

During the night there will be lulls in activity. Use these to walk around and get warm to keep you going through until dawn.

The Northern Hemisphere

Aquarius and Pegasus grace the skies of September, marking a change in the observing season

With the Sun setting not long after 7pm (BST) this month, rich pickings can be had by those with even modest observing equipment. The end of September affords a last chance to catch the likes of Cygnus (the Swan) and Capricornus (the Sea Goat) and their wealth of deep-sky objects.

Look out for the 'square' of Pegasus (the Winged Horse) rising in the west, while Cepheus (the King) appears in the northwest. In both a selection of binary stars can be split using small telescopes. Aquarius (the Water Bearer), Taurus (the Bull) and Orion (the Hunter) offer globular and open clusters along with glowing star-forming regions, which are a breeze to pick up through binoculars and even the naked eye with low light pollution.

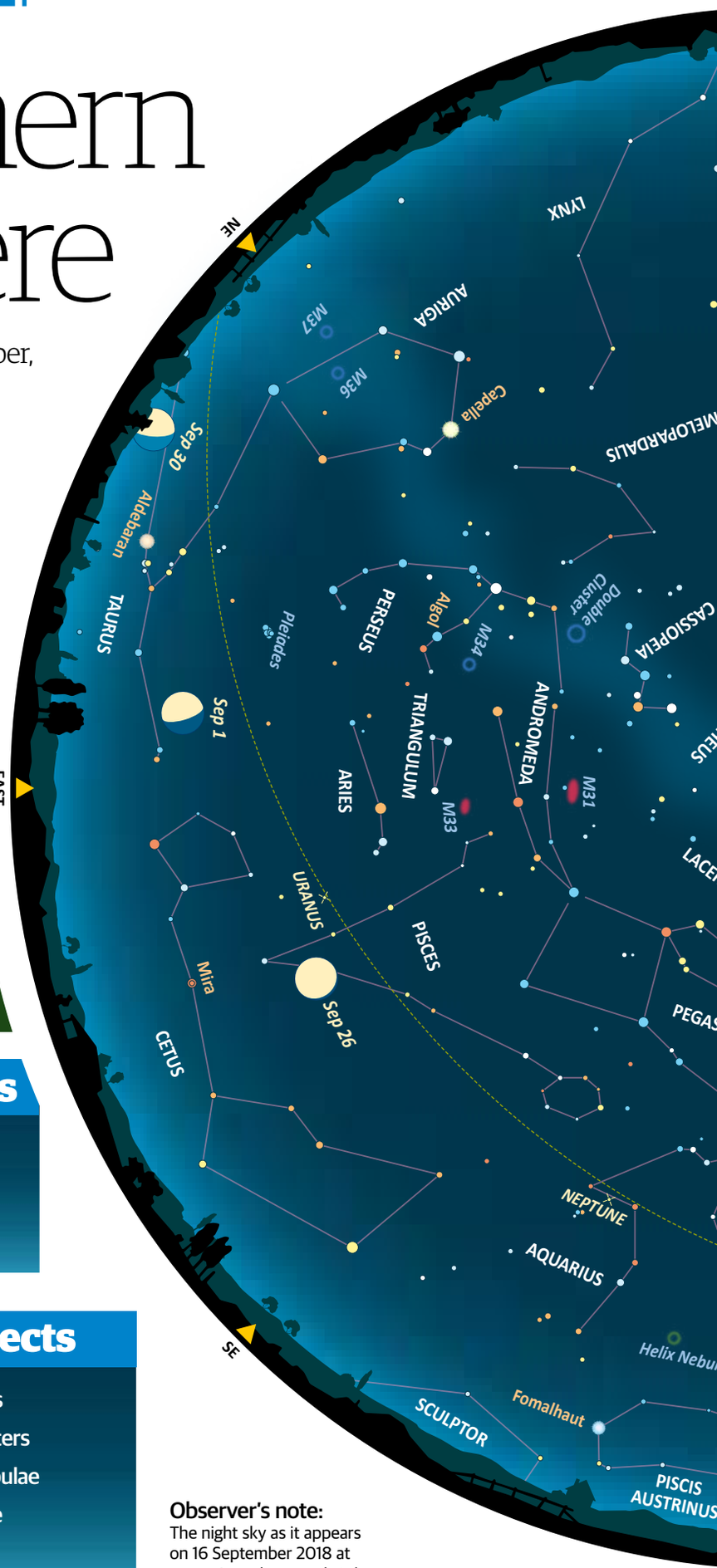
Using the sky chart

This chart is for use at 10pm (BST) mid-month and is set for 52° latitude.

01 Hold the chart above your head with the bottom of the page in front of you.

02 Face south and notice that north on the chart is behind you.

03 The constellations on the chart should now match what you see in the sky.



Observer's note:
The night sky as it appears on 16 September 2018 at approximately 10pm (BST).

Magnitudes

- Sirius (-1.4)
- -0.5 to 0.0
- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- Fainter
- Variable star

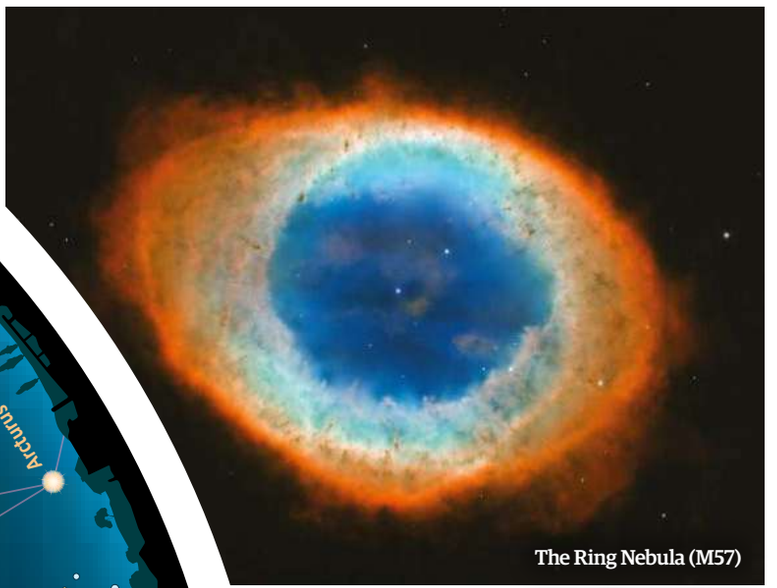
Spectral types

- O-B
- A
- F
- G
- K
- M

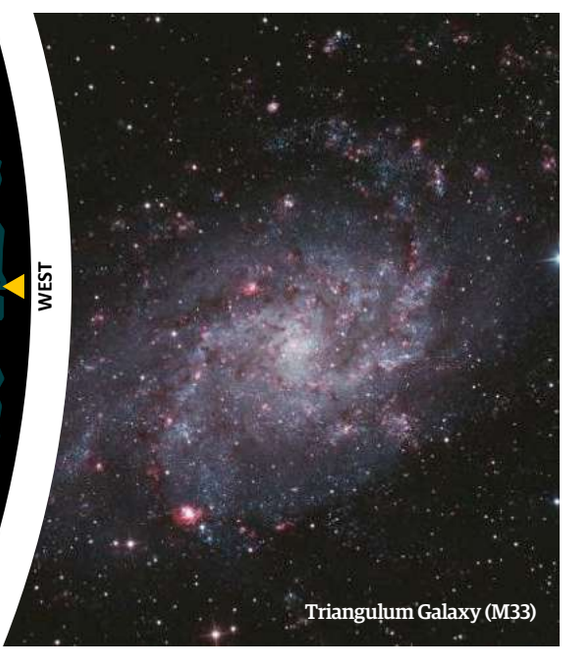
Deep-sky objects

- Open star clusters
- Globular star clusters
- Bright diffuse nebulae
- Planetary nebulae
- Galaxies

The Northern Hemisphere



The Ring Nebula (M57)



Triangulum Galaxy (M33)

Dumbbell Nebula (M27)

Astroshots *of the month*

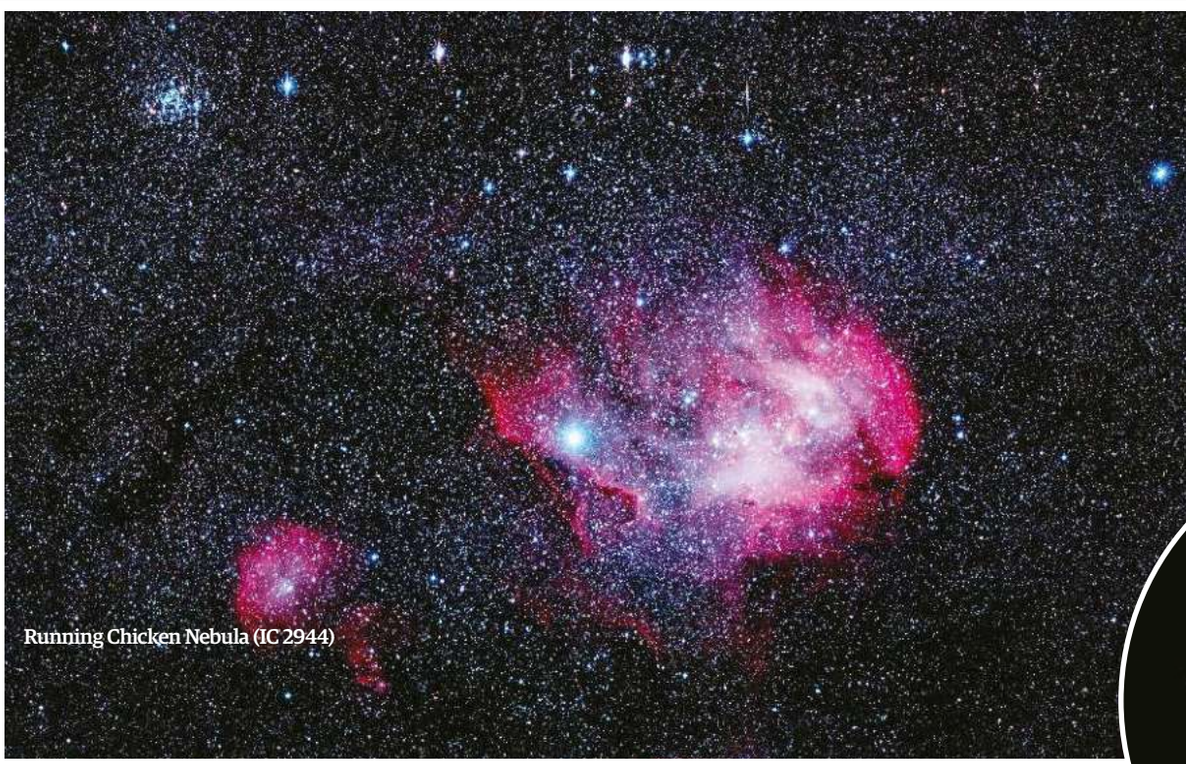
Send your astrophotography images to **space@spaceanswers.com** for a chance to see them featured in **All About Space**

Eta Carinae

Ian Griffin

Dunedin, New Zealand

"Just over three years ago, a new job meant that I moved from Oxford in the United Kingdom to Dunedin on the South Island of New Zealand. Since moving I've developed a passion for astrophotograpy, both with and without a telescope. The Southern Hemisphere sky is teeming with fascinating objects, and it's a real pleasure to live in a part of the world where the centre of the galaxy passes overhead in winter. Here in Dunedin we also get frequent displays of the aurora australis, which can look truly spectacular against the backdrop of the beautiful New Zealand landscape."



Running Chicken Nebula (IC 2944)

Paul Swift

Valencia, Spain

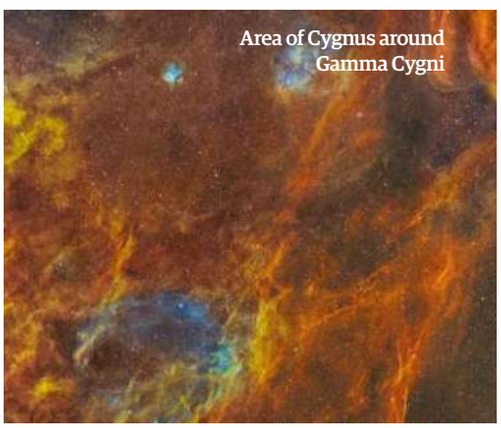
"I have a background in the arts and worked professionally as a cinematographer and lightning cameraman – astrophotography made for a natural change in focus. I have always wanted to turn my camera to the night sky, and moving from London to the less light-polluted Valencia, Spain, presented me with the perfect opportunity to do just that.

"The combination of exploring deep space and the creative and technical art form that is astrophotography has offered a powerful and alluring vocation. On any clear night I can be found setting up under darkening skies for a night of astrophotography."

Horsehead Nebula (Barnard 33)

California Nebula (NGC 1499)

Great Orion Nebula (M42)



Area of Cygnus around Gamma Cygni

Ronald Zincone

Richmond, Rhode Island

"I enjoy all forms of astrophotography – yes, it is challenging and frustrating at times, but also very rewarding! To be a serious astroimager you must be prepared to sacrifice sleep, travel to dark-sites, be diligent, patient and enjoy 'hands-on' learning."

Milky Way, Jupiter and satellites over Nauset

Crescent Moon

Send your photos to... @spaceanswers space@spaceanswers.com

Sky-Watcher Explorer-130PS (AZ PRONTO)

Perfect for astronomers on the go, this exquisite Newtonian has been built with the beginner in mind

Telescope advice

Cost: £219
From: Optical Vision Ltd
Type: Newtonian
Aperture: 5.11"
Focal length: 25.59"

Best for...

- Beginners
- Low budget
- Planetary viewing
- Bright deep-sky objects
- Basic astrophotography

This 'scope is simple to assemble, easy to use and gives good views of some of the most popular targets

A telescope that can be easily transported to sites untouched by light pollution has great appeal whether used by a beginner or a more seasoned astronomer – and that's exactly the sort of telescope Sky-Watcher's Explorer-130PS is, fitting the bill nicely as a 'grab-and-go' instrument. The telescope and its AZ PRONTO mount are a compact and light package. Assembly and operation are user friendly in the hopes of providing a welcoming introduction to observing the night sky, making it an ideal telescope for those new to touring the heavens.

It uses a Newtonian reflector design that employs a parabolic primary mirror to collect and focus the light, and a flat secondary mirror to reflect it to the eyepiece. This design requires collimation to align the two mirrors accurately with one another and the eyepiece. But, to make life easier for beginners, a large chunk of this potentially perplexing process has been removed. The telescope has a fixed mirror cell for the primary mirror which is collimated at the factory, so it'll only require occasional adjustment to the secondary mirror, for which a suitable Allen key is supplied. Upon delivery the review telescope was in excellent collimation and produced well-formed stars during this test – it really did work well straight out of the box. The AZ PRONTO mount didn't disappoint and was quick to assemble, providing a sturdy platform for the telescope. An accessory tray for your eyepieces also serves to help stabilise the entire set-up – we discovered that there was minimum shaking during our observations and sufficient resistance against the light breeze that picked up throughout the course of the evening. Adjustments with the mount are smooth and it's easy to keep objects centred in the tube's field of view.

The optical system provides exquisite views of an excellent selection of targets

The Explorer-130PS also comes with a pier extension to keep the telescope from clipping the tripod legs while slewing – something that got a lot of use throughout our review of the instrument.

The Explorer-130PS' steel optical tube is finished in a high-gloss black with a silver-flecked finish,

"Upon delivery the review telescope was in excellent collimation and produced well-formed stars"

The supplied red dot finder is an excellent choice, especially for beginners

making it aesthetically appealing, cradled in two substantial felt-lined tube rings, which are attached to a Vixen-style dovetail bar. The dovetail bar feature isn't used to attach the telescope to the mount. Instead, a bolt on the mount is screwed into a matching threaded hole in the base of the bar – pleasingly, no slippage was experienced during our review of this feature.

A rather basic, plastic, single-speed rack and pinion focuser completes the optical tube, but despite some initial reservations we found this to be effective in use. With it we were able to achieve focus amazingly quickly and easily.

The supplied red dot finder is certainly an excellent choice, especially for beginners, as it's so easy and intuitive to use. Over a smaller, optical finderscope, we relied on it extensively for star hopping to a selection of deep-sky objects that peppered the mid-summer, evening sky.

With its focal length of 650mm, the Explorer-130PS is a good compromise for observing a wide range of objects in the Solar System and deep-sky categories. Taking our observations until dawn, we enjoyed some excellent views of Mars in the small hours of the morning, then a variety of open clusters boasting its wide-angle capabilities. In both the 25mm and 10mm eyepieces the rugged lunar surface was a wonderful sight through this telescope, sure to delight those who have only just been introduced to astronomy.

Overall, the scope and mount package was a pleasure to use. It's simple to assemble and easy to get to grips with, while its optical system gives good views of popular targets. With no immediate, teething faults, the Explorer-130PS gets a massive thumbs up from us!

Adjustments on the mounts are smooth and it's easy to keep objects centred in the field of view

Two eyepieces are supplied - a 25mm and 10mm

WIN!

AN ALTAIR ASTRO COLOUR CAMERA

For when just seeing isn't enough, get your hands on this fantastic CMOS to image the night sky

Courtesy of Altair Astro, the pocket-sized, but powerful Altair GPCAM2 IMX224 camera provides magnificent sights of the cosmos – and we're giving one away!

Because of its simplistic design, all you need to do is connect it to your laptop and insert it into the eyepiece of any telescope, as it is compatible with all 1.25-inch fittings. With Windows-compatible software, it is incredibly easy to use while allowing the user to adjust any settings to their liking; offering flexibility for beginners to advanced astrophotographers.

Capable of imaging the wonders of the Solar System and beyond, users can start by photographing the Moon, moving on to Jupiter and its moons and even shoot some fantastic star clusters and bright nebulae. A camera that will keep anyone busy for a night of observing, all you need to do when you're done is pop the cap on and put it back in your pocket.

To be in with a chance of winning, all you have to do is answer this question:

What was the name of the last orbiter to be used in NASA's Space Shuttle program?

A: Atlantis **B:** Endeavour **C:** 7 Iris

Congratulations to Cameron Keegan, who is the winner of the astronomy backpack bundle

WORTH £259

ALTAIR

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Book Columbus in Space

Cost: £8.99 **From:** European Space Agency / Penguin Books

Sometimes it is easy to forget that the International Space Station (ISS) is not purely a NASA affair, but it is a truly global project, as this book from the European Space Agency (ESA) and Penguin Books reminds us. It tells the story of the ISS' Columbus module, built by ESA and attached to the space station in February 2008 in a procedure that took 12 days and 18 hours.

The prose tells us to think of Columbus as a flying science laboratory conducting dozens of experiments each year in such varied fields as fluid physics, physiology in space, solar monitoring, humane biological research on animals and plants, micrometeoroids and Earth observation.

The Columbus module cost 1.4 billion Euros to complete, and among the many facts presented in this anniversary book, is the fact that 5,161 people have been involved in Columbus' science experiments over the last ten years. A great introduction to Columbus, which allows many more people to learn about how the ISS is doing science in from Earth orbit.

Accessories Exoplanet v 17.1.0

Cost: Free **From:** iOS

Highly visual and interactive, Exoplanet allows you to keep up to date with the latest discoveries of alien worlds. Developed by professional astronomers, this app features a stunning 3D model of our galaxy, revealing the locations of all known exoplanets. We enjoyed the zoom function, which allows the user to get a close-up 'view' of planetary systems. If you've ever wondered what the night sky looks like from these alien worlds, then you're in luck: Exoplanet provides such a feature, as well as a push notification when another world is found and where you can find these exoplanets in the night sky in real time.

Essentially a catalogue or database of discoveries, Exoplanet provides detailed information on every confirmed world in a visual way. The graphics aren't massively detailed, but given that it's clear which exoplanet you're observing at any one time this didn't affect our experience. The app has been consistently revised and improved, fixing any bugs that affect the running of the app. However, despite being in its 16th version the app still continues to crash, forcing us to shut our device down on several occasions. This became quite frustrating after the seventh time of restarting the app.

Software Starry Night Pro

Cost: £38.99 (approx. $50.00) **For:** Windows, Mac

Dubbed the 'most realistic' astronomy software, Starry Night Pro certainly lives up to the hype. Its graphical performances as well as its huge package of options that contain everything the serious astronomer needs make this a must to own by those keen on the wonders of the night sky.

Starry Night Pro, which is available for Mac and PC, comes with a wide selection of objects - including 16 million stars, over 19 million objects up to magnitude 15 as well as 73,197 galaxies. Of course, Starry Night Pro is also massively educational and, provided you have QuickTime installed on your computer, users can watch a wide selection of movies, including sky animations, planet flybys achieved by NASA missions and rocket and spacecraft launches. This astronomy software also allows you to travel beyond the Solar System in 3D up to 700 million light years away and create planets with customisable surface details and satellites. You can also go back or forward in time by 99,999 years to observe the sky and track asteroids and comets.

Given its massive amount of data, Starry Night Pro requires a computer with a large amount of RAM and hard disk space. If this doesn't worry you and you have had an interest in astronomy for a long time then we strongly recommend this program.

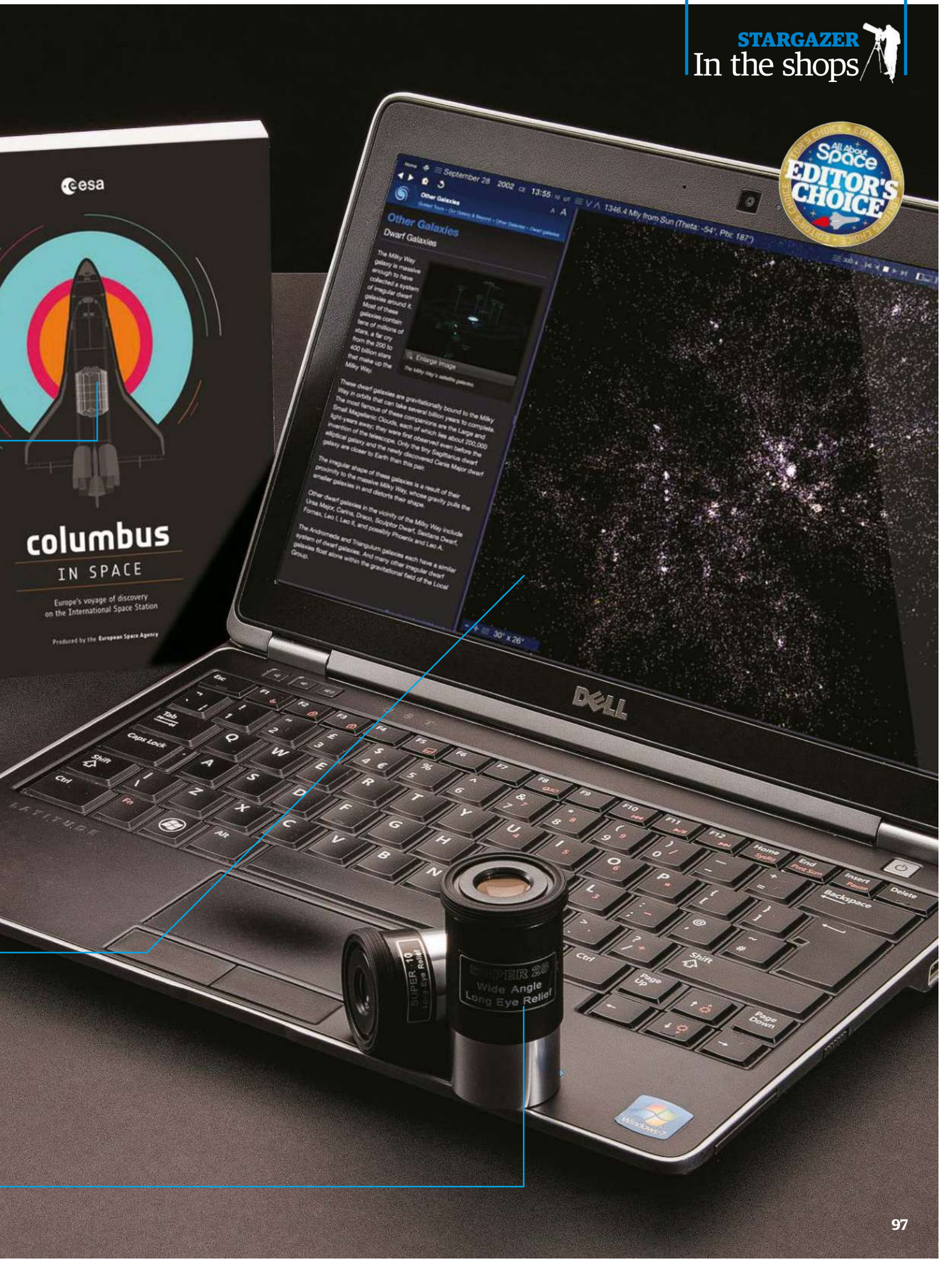
Accessories Sky-Watcher SP Plössl eyepieces

Cost: £20-£29 **From:** First Light Optics

We think that a telescope is often only as good as its eyepiece, but the best accessories can sometimes cost almost as much as the telescope. Finding affordable, high-quality eyepieces is an important task, and Sky-Watcher's range of SP Plössl eyepieces, with focal lengths ranging from 6.3mm to 40mm, fit the bill.

Plössls contain two sets of two lenses, known as achromatic doublets, which help set them apart from standard eyepieces that may get lumped in with your telescope purchase. When testing these 1.25-inch eyepieces on a six-inch f/4 reflector we were pleased with their performance, which delivered excellent pinpoint views of stars across their 50 degree field of view. The Moon revealed excellent clarity and brightness, with no apparent distortion or spherical aberration. The eyepieces feel solidly constructed, with the larger eyepieces in the range benefitting from rubber grips, though we imagine you might end up dropping the smaller eyepieces from numb fingers during cold winter nights. Glasses-wearers, however, may find that the SP range lacks adequate eye relief, even on the longer focal length eyepieces.

"They delivered excellent pinpoint views of stars across their 50 degree field of view"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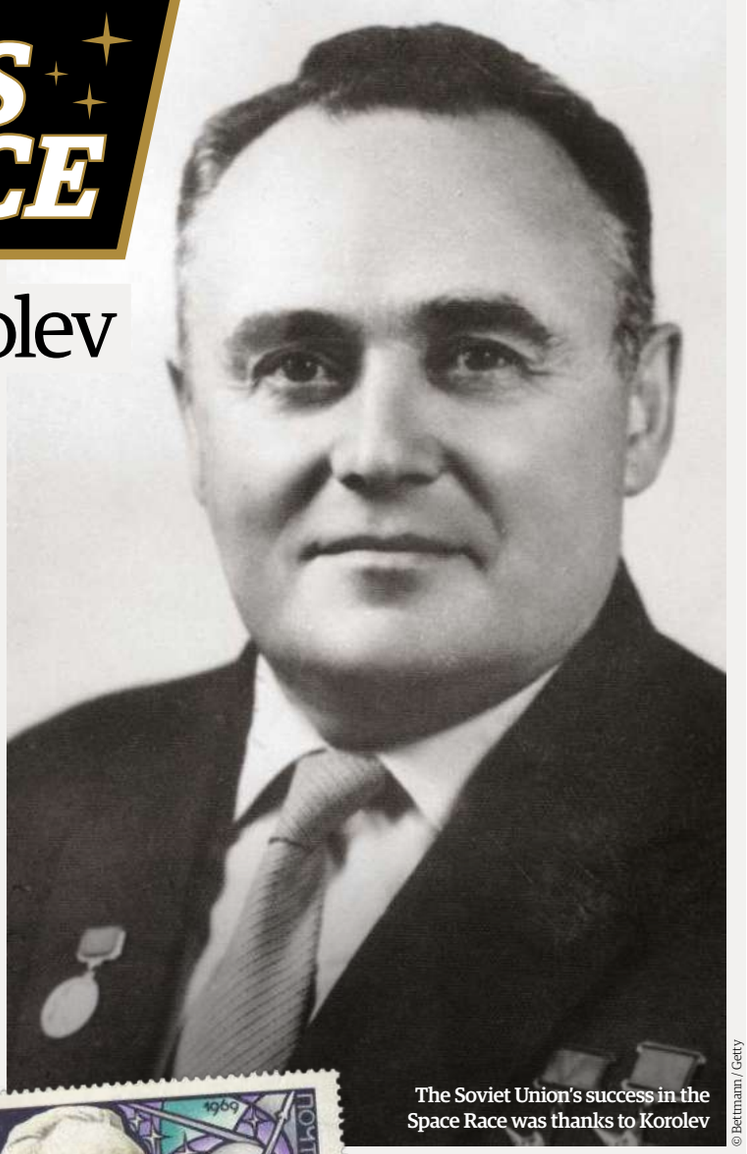

The Soviet Union's success in the Space Race was thanks to Korolev

© Bettmann / Getty

Although not a household name, Sergei Pavlovich Korolev was the lead rocket engineer for the Soviet Union during the intense years of the Space Race that flared during the 1950s and 1960s. Under the tenure of Korolev the Soviet Union saw spaceflight evolve greatly, with many milestones we look back on today as revolutionary.

Born on 12 January 1907 in Zhytomyr, Ukraine, Korolev was fascinated by aircraft from an early age and was even designing his first glider by the age of 17. He graduated from the Kiev Polytechnic Institute and joined the Bauman Moscow State Technical University where his interests migrated towards rocket propulsion, which was only a theoretical subject at the time.

During the mid-1930s the Soviet Union was in a dark time under Joseph Stalin as the 'Great Purge' was underway. This movement was all about prosecuting Stalin's perceived opponents, and Korolev's colleague, Valentin Glushko, was taken as part of this. Glushko then turned Korolev in on 23 March 1938, who was arrested and sentenced to ten years of hard labour.

Korolev spent two years in various jails before being allowed to join an Experimental Design Bureau – a labour camp for engineers and scientists – at the request of his old mentor Andrei Tupolev.

In November 1944 Korolev was out of jail and was leading his own team that was responsible for the Soviet's rocket equivalent of Nazi Germany's V2 missile. After many years of development at the drawing board Korolev and his team created the R-7 booster rocket, a pioneering rocket in space history as it was the first intercontinental ballistic missile (ICBM).

On the 4 October 1957 the world witnessed the launch of the famous Sputnik 1, the first ever human-made satellite, aboard an R-7 rocket. This was an important milestone in the Space Race as it made clear that the Soviets were ahead their rivals, the United States.

The next step was to get a living creature into space, and this happened during the following month. Aboard Sputnik 2 and another R-7 rocket was Laika, the heroic dog who became the first animal to make an orbit of the Earth. Unfortunately there was no mechanism to bring the dog back to Earth, and Laika died from heat exhaustion within five hours.

The 1960s had rolled around, and Korolev was determined to send a Soviet cosmonaut to the Moon. This was intensified by the launch of the first manned spaceflight. On board the Vostok 3KA-3 spacecraft, a member of the R-7 rocket family, was the calm, cool and composed Yuri Gagarin, who flew around the Earth once and safely parachuted back to ground.

This breakthrough was followed by the first lunar surveillance missions, Luna 1, 2 and 3, but the United States won the manned race to the Moon. Without the efforts of Korolev the Soviet Union wouldn't have even got off the ground. He was incredibly influential when it came to these space milestones, but it is the names of Laika and Gagarin that are remembered. Korolev would never see humans land on the Moon as he passed away from cancer on 14 January 1966, five months before the Apollo 11 lunar landing.

"Korolev and his team created the R-7 booster rocket, a pioneering rocket in space history as it was the first intercontinental ballistic missile"

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93%

SRP £559

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- Parabolic Primary Mirror
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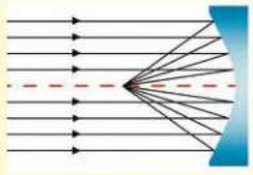

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